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Ceramics

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The Research Associations and the Independent Consultant

• *by Argus* •

WE tend to decry American practice—sometimes truly and at other times with a spirit of envy. However, it is always as well to look at another country's approach to problems bearing in mind their national conditions. When this is done actions which appear, at first, to be unsound can often be proved to be advantageous for the country in question.

The position of the Independent Consultant differs largely in Britain and in America. For example the American Mellon Institute and the Battelle Memorial Institute have technical staffs of about 800 between them. They will tackle almost any technical problem on behalf of any commercial organisation. They have well equipped laboratories and technical staffs who are expert in a variety of fields. In addition to these two there more than a score of other industrial consultants with staffs ranging from 30 to 100.

British Organisations

In Britain the only parallel organisations are the Sondes Place Research Institute at Dorking and the Fulmer Research Institute in Buckinghamshire whose total staff number rather less than 100!

These newer research institutes tackle problems largely in the same way as their American counterparts and in the last year or so they have

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spent many thousands of pounds in providing that range of laboratory equipment which is essential to give service to industry.

But it is as well to examine British industry in relation to these research establishments. The British manufacturer has never taken kindly to the Independent Consultant—certainly not to the same extent as has happened in America. This can be attributed largely to the traditional growth of British industry. Two or three workers more or less in secret produced something which they thought would meet a demand and having carried out their work they began to make the article and to sell it

The average British manufacturer is happy to pay a licence fee for the use of a piece of equipment if this is disguised in the price of a proprietary article. But their reaction to paying a licence fee as a separate bill is one of extreme reluctance. In fact there are very few businesses which can be considered as successes in Britain which are dependent upon the customer paying a separate licence fee.

In the same way there is an equal reluctance for British manufacturers to pay a consultants fee for what they consider to be only a paper report and advice. The average British manufacturer would rather muddle along with his own perhaps limited resources of technical knowledge. He is quite prepared to pay 7s. 6d. for a "Dear Sir, Unless . . . . . " letter by his solicitor. But to pay for a letter from a consultant which can quite possibly save him a considerable amount of money is worse than extracting his tooth!

"Paper Consultants"

This attitude has not been without its reaction upon many of the so-called consulting services which have been evolved. The result has been an unfortunate tendency for consultants to become what are described as "paper consultants" with no laboratory facilities, or at the best limited to routine analytical work. Then the consultants themselves have to some extent become wedded to certain equipment suppliers and in some instances have become agents more or less for such suppliers.

Because of the refusal of manufacturers to pay consultants fee it has been in many cases necessary for the consultant to obtain his remuneration as a percentage on the value of the equipment supplied by the supply house. In other words the user has paid the consultants fee but has paid it indirectly and of course the consultant finds himself in a most difficult position when he has to arbitrate between services to the user whilst he simultaneously is paid by the supplier. The British Independent Consultant, as such, therefore lives in a peculiarly difficult world.

There is no doubt that there is considerable scope for the Independent Consultant in the clay working industries. We cannot expect in the next decade that our understanding of the fundamental chemistry and physics of clay is going to be revolutionized.

Nevertheless the accumulated empirical knowledge of this raw material is vast. Where modernisation and manufacturing development in the clay working industries show the most profitable return is in the reduction of labour necessary to produce a single production unit. The same handling techniques which have been adopted in the metal working industries, in confectionary manufacture, in brewing, in the chemical industry, in foundries and in paint shops, can and are being applied in the clay industry. There is much to be said for the Independent Consultant who is not an expert on any particular field but who by virtue of his business meets a variety of people in different industries. He can often see the wood between the trees!

An Impartial Survey

However, the Independent Consultant of most use to the clay working industry is the one who has laboratory resources and not the "paper consultant" who very soon becomes a glorified human card index system. There is no doubt that if the empirical knowledge were imparted to the Independent Consultant and he was also provided with a cost breakdown on the job as it exists he would be in the position of offering a scheme of modernisation working in conjunc-

tion with the manufacturer which would be distinctly impartial and of value to the industry.

However, tradition dies hard and the consultant who is offering this service has got a tremendous problem ahead in selling the proposition to the British manufacturer.

But what is 100 guineas for an impartial survey of a project which might cost tens of thousands of pounds? If a truly independent opinion can be obtained then there is no doubt that the manufacturer or user could benefit considerably!

Guarded Recommendations

Whenever this question of development arises there is a tendency for the manufacturer who subscribes to a Research Association to expect the work to be carried out there. However, the Research Association is in a particularly difficult position in arbitrating between its various members. At the best it can but initiate research and development programmes which are largely fundamental in character and which are likely to benefit the highest proportion of its members. There again the recommendations of a Research Association must of necessity be very guarded. They must not open themselves to an accusation that they are more favourably inclined to one manufacturer of equipment than another.

The result is that they accumulate from experience a large volume of data showing the advantages and disadvantages of certain equipment but since user and supplier are members of the same Research Association the latter could hardly issue a report condemning one aspect of a supplier's equipment even though they know and realise its limitation. Then on the other hand they must not eulogise even a good piece of equipment unduly because they then open themselves up to attack by being too favourable!

Therefore the research programmes of a Research Association tend to become concentrated or non-controversial topics. Of course, it is just the controversial topics which are of most use to the trade itself!

Heavily Subsidised

Then of course many of the Research Associations have virtually become part of the Department of Scientific and Industrial Research and are heavily subsidised by the Treasury. Once State sponsorship creeps into the Research Association then they must be even more guarded in their comments and criticism and the results of investigations are most certainly heavily censored before the reports are issued. This censorship is not necessarily for technical accuracy but is more frequently in the light of possible members repercussions or recriminations!

Avoid Political Criticism

In other words politics is very much a part of the policy of a Research Association and there is no doubt from conversations I have had with many of the directors of different Research Associations that their biggest problem is to avoid political criticism of their findings. There is less chance of such criticism on a piece of purely academic research and so in desperation the programmes of the Research Association are heavily balanced in favour of this type of research. When it comes to application and industrial usage with a firm recommendation as to which type of equipment should be used or should not, it is almost impossible to expect the Research Association to give a definite "yes" or "no." The more research and development becomes part of a state enterprise the less is the subject of the research related to everyday practice. It is an insuperable problem and one solution does lie in the greater use of the Independent Research Consultant. He issues his reports in confidence to his client and can make firm recommendations in the same manner as a solicitor.

Misuse of Technical Skill

There is no doubt that a considerable volume of technical skill is being misused in many of the State sponsored Research Associations. To keep life fairly easy many of their directors tend towards highly academic scientific polemics rather than deal with the political dynamite of day-to-day production problems. There are only a few brave souls among them!

Organic Binders

(SPECIALLY CONTRIBUTED)

THE term "organic binders" is a short description for a wide class of substances used to increase the plasticity and/or the dry strength of ceramic materials. They are termed "organic" because they contain carbon compounds of the type found in living organisms or, as the chemist calls them, organic compounds.

No New Development

The use of organic binders is no new thing. The old saying that you cannot make bricks without straw may have had some reference to the addition of organic matter in the form of rotted straw to modify the properties of clay, to make it more suitable for moulding into bricks, though more probably the straw was added as a kind of reinforcement in the building of clay walls. Whatever the real answer may be the matter merits no further discussion here, for bricks certainly are not made with straw in these days, in fact the common brick clays have no need in general of any added substance to enable satisfactory manufacture of bricks to take place.

In the pottery trade, to give a well-known example, the use of gums to improve the plasticity of short bodies such as bone china and porcelain has been known for a very long time, in the manufacture of such specialities as baskets and flowers. Such articles are made by hand. Flower petals are moulded with the aid of a metal spatula, while in making baskets, the body is extruded as thin cords, which are woven into the finished article by hand.

In the ordinary way bone china body lacks the necessary plasticity for this, and when dry the articles are so brittle that the losses on handling are great. The addition of a small amount of gum arabic to the body improves the plasticity and the dry strength so that these losses are greatly reduced. The operatives use a little vegetable oil on the hands to prevent the body sticking to the fingers. It is a fascinating sight to see how easily a skilled worker, with no complicated apparatus, can produce the most beautiful flowers from shapeless masses of clay. Equally fascinating are the gorgeous colours that they take on in the subsequent decoration. The gum, of course, burns away on firing, and so little is used that the properties of the fired body are almost unaffected. The use of binders in the refractory industry is also a well-known practice.

In some cases the use of clay for shaping is impossible because of its effect on the refractoriness of the fired article. Consequently the use of high pressures for moulding, often accompanied by the use of a binder to give strength to the unfired product, is common. Thus we have the use of sulphite lye in the manufacture of silica bricks to reduce handling losses after moulding in the press, and the use of gums for binding cores of moulding sand in the casting of metals.

The shaping of ceramic wares of certain types without the use of clay is thus an accomplished fact, and some far-sighted ceramists have visualised the manufacture of other materials, like pottery, without the aid of clay. The necessary ingredients would be added and bonded with some synthetic material, which would fire away. This would cut out the attendant troubles which follow from variations in the composition of natural clays. So far no such material is available which would be cheap enough to compete with clay in those sections of the industry in which it is traditionally used.

Variety of Substances in Use

The use of binders has received considerably more attention in the United States of America than it has

in this country. During the 1944 meeting of the American Ceramic Society it was arranged to send a questionnaire to all users of these substances, and to classify and publish the results. This was done in the Bulletin of the American Ceramic Society in the same year (J. W. Whittemore. [3]). The number of substances described was very great—approximately 100—and these appear to act either as plasticisers, i.e. substances which increase plasticity—or as adhesives, increasing the strength of the articles when dry prior to firing.

Properties of Binders

The action of binders in improving the working characteristics of non-plastic materials has been investigated by C. C. Treischel and E. W. Emrich (2) and by E. P. McNamara and J. E. Comeforo (1).

The former worked on the extrusion properties of mixtures of talc and water with various binders, and the latter on the pressing properties of similar mixtures with flint instead of talc. In this way the action of the binder could be studied without the uncertainties introduced by variability in the plasticity of bodies containing natural clays.

A selection of their results is given in Tables 1 and 2. For the fuller results the original papers should be consulted.

It is to be noted that in all cases the binders increased the dry strength, as measured by the modulus of rupture, and from Table 1 it also appears that they increased the time required for drying in air. Drying shrinkage was greater than with the untreated material, as was to be expected. Treischel and Emrich concluded that the best possibilities existed with the gums, alginates, and alcohols and celluloses, though price would probably restrict their use. In such cases flours, starches, and wood extracts were possibilities.

Effect on Fireclays and Shales

As far as fireclays and shales are concerned J. O. Everhart (5) has given a number of interesting results to show the effect on physical properties of adding small amounts of some typical binders. These are summarised in Table 3.

TABLE 1 TALC-WATER SYSTEM

Binder	*% used*	*Dry Shrinkage %*	*Modulus Rupture lb./sq. in.*	*Water of Plasticity %*	*Days to dry in air*	*Extrusion Characteristics*
None	-	4·3	30	25·1	3	Fair
Flours and Starches						
Potato Starch	1	6·0	430	24·3	5	Good
Dextrin	1	5·7	350	24·2	4	Fair
Gums						
Gum arabic	1	6·7	480	24·9	5	Good
Tragacanth	1	5·3	490	25·4	5	Excellent
Acacia	1	5·7	540	23·2	7	Good
Alcohols and Cellulose Derivatives						
Methyl Cellulose (Methocel)	1	5·3	1230	23·6	6	Good
Polyvinyl Alcohol (Elvanol)	1	6·3	440	25·4	4	Fair
Hydroxy Methyl Cellulose	1	5·3	610	23·3	4	Good
Wood Extracts						
"Plasticode"	1	3·7	90	23·5	3	Fair
"Goulac"	1	3·3	560	22·5	6	Fair

NOTE: Higher percentages of binders up to 3 and 5 per cent. gave higher values for Modulus of Rupture. The original paper should be consulted for the full results. (C. C. Treischel and E. W. Emrich. [2].)

TABLE 2 FLINT-WATER SYSTEM

Binder	%	% Water when Pressed	Modulus of Rupture (lb./sq. in.)	Pressing Characteristics
Gelatin	2	11·9	2405	Good
Casein (13% soln.)	2	12·0	2010	Very Good
Peptone (40% soln.)	2	10·2	595	Fair
Gum Ghatti	2	12·4	850	Laminated
Dextrin (50% soln.)	5	12·2	1000	Good
Ditto (commercial)	5	12·4	605	Stuck
Cornflour	2	12·5	530	Good
Wax Water Emulsion	5	11·8	45	Good

Fuller results for these and other binders are given in the original paper. (E. P. McNamara and J. E. Comeforo, [1].)

TABLE 3 (J. O. Everhart [5])

Binder	%	Body	Unfired Strength lb./sq. in.	% Drying Shrinkage	Fired Strength lb./sq. in.	Total Shrinkage %	Porosity %
Lignin Extract (1)	0	Fire Clay	342	5·0	3005	11·5	5·5
	½		616	5·5	3240	11·2	6·9
	¾		830	4·9	3183	11·0	6·3
	1		958	5·4	2893	10·5	7·0
	2		1314	4·8	2790	10·2	7·1
Cooked Wheat Flour	0	Fire Clay	250	4·5	3100	10·1	6·2
	½		420	5·0	2470	10·2	7·5
	1		575	5·1	2395	10·3	8·8
	2		700	5·2	2210	10·5	9·2
Corn Cereal Binder	0	Fire Clay	210	5·1	2915	10·3	6·9
	½		315	5·3	2970	10·4	6·9
	¾		400	5·5	3050	10·7	7·2
	1		540	5·5	2715	10·6	7·8
	2		700	5·5	2400	10·7	9·0
Polyvinyl Alcohol	0	Fire Clay	170	5·0	2700	11·5	5·5
	½		250	4·6	2850	11·0	7·0
	¾		250	4·4	2510	10·4	8·3
	1		475	4·2	2310	10·6	8·6
	2		540	4·1	1875	10·1	8·8
Lignin Extract (92)	0	Shale	415	3·2	3970	12·1	2·1
	½		620	3·4	4125	11·8	2·2
	¾		710	3·3	4090	11·7	2·3
	1		772	3·1	3765	11·7	2·2

Classification

The binders then fall into the following rough categories:—

Class	Examples
Flours and starches	Wheat and corn flour, potato starch, dextrin
Gums and alginates	Gums arabic, ghatti, acacia, and tragacanth Alginic acid and alginates
Alcohols and cellulose derivatives	Polyvinyl alcohol, methyl cellulose, hydroxyethyl cellulose, carboxymethyl cellulose
Proteins	Casein, gelatin
Wood extracts	Sulphite lye, etc.
Compounds of silicic acid	Silicon esters
Miscellaneous	Resin, rubber, etc.

Flours and Starches

The significance of the results already given is that the addition of small quantities—in some cases a fraction of 1 per cent. of these compounds can greatly increase the dry strength of ware, and thus reduce losses in handling, or in some cases make it possible to use materials lacking in plasticity, such as refractory oxides. Flours and starches have little effect on the plasticity, but increase the unfired strength of the body. The shrinkages of the body are increased and, due to the burning out of the binder, the fired porosity and strength are somewhat less. These binders are relatively cheaper than many other types.

Proteins

Protein materials are relatively more expensive to use, though they also improve strength. A well-known example of the use of gelatine is in the preparation of glazes for painting on fireclay sanitary ware. Its use thickens the glaze and gives it strength when dry, preventing it from being knocked off.

Polyvinyl Alcohol

The uses of polyvinyl alcohol in the form of a water-soluble resin formed by the condensation of the alcohol have been described by L. Brown and L. Coffin (7). They found that this could be added to a slip composed mainly of china clay and Florida kaolin with marked improvement in properties. It was added in the form of the completely hydrolysed water-soluble resin in amounts of 1 per cent. or less of the total slip. Casting time was not increased, and there was no adverse effect on the mould. Jiggering operations were made easier, as the tool wear was reduced, and the finished ware was dried in the usual times. Its green strength was increased by approximately 35 per cent. with consequent reduction in handling losses. The resin had no effect on the fired colour and translucency of the ware. Because of the improvement of the workability of the body, operatives could be trained in a shorter time.

The resin has also been used in the U.S.A. during the war as a substitute for gums which were then not readily available, particularly as a binder for steatite insulators prepared by extrusion. The water soluble resin, in amounts of 3 per cent. on the weight of dry body is added to the dry ingredients. The particular resin used was a partially hydrolysed one of low viscosity. It improved the mixing qualities and, acting as a die lubricant, permitted extrusion of the body at a lower pressure. The surface was smooth and free from blemishes. No sign of migration of the binder to the surface was noted on drying, and the dry strength was improved, so that handling losses decreased.

Cellulose Derivatives

These are complicated chemical compounds, which dissolve in water to give viscous solutions. In this country a range of cellulose compounds are sold under the trade name "Cellofas." Methyl ethyl cellulose is marketed as Cellofas A. It is a white solid, soluble in cold water. A 1 per cent. addition to clay bodies lacking in green strength makes it possible to extrude narrow tubes with less extrusion and handling breakages, as the material acts as a binder, and also as a die lubricant.

Cellofas B is sodium carboxymethyl cellulose, and is also water soluble. It finds application in improving the suspending powers of glazes, and as a binder. In general, quantities of from 1-3 per cent. are added. Being a synthetic product, its purity can readily be checked. Like other organic binders it fires away.

Wood Extracts

Wood extracts have a somewhat more general application as binders than some of the other substances which have been mentioned because they are by-products of industry, and therefor relatively low in price. Wood consists of cellulose and the fibres, or lignin. The latter is dissolved away by boiling with a solution of calcium bisulphite, and the cellulose separated and well washed. The lignin extract, sometimes called "sulphite lye," is sold either as a solution, or as a solid of somewhat variable composition. It may be added to the body mix either as solid, or as a solution. A well-known example of its use is the manufacture of silica bricks from crushed ganister. The latter is mixed with 1-2 per cent. of milk of lime to act as

a flux, and at the mixing trough, a similar quantity of sulphite lye is added to give strength to the green bricks. These are very fragile as they leave the press, and, even with the addition of the binder, require careful setting in the kiln.

J. O. Everhart's data in Table 3 shows the effect of its addition to fireclay bodies and shales.

A very small addition produces a great improvement in unfired strength, and, although further additions improve the strength, the increase is not proportional to the amount of binder added. The fired strength also tends to increase with additions of up to ½ per cent., but thereafter decreases. Porosity increases with addition of lignin extract, due possibly to burning out of carbonaceous matter in the binder. According to the same author plasticity is increased by the addition of lignin extracts, and the rate of drying is not increased to any appreciable extent. The cost of the binder is such as to be a practical proposition for heavy claywares. The cost of adding sufficient to double the green strength of such ware is only a few shillings per ton, and markedly reduces the losses on handling. Its use is especially recommended for tender clays.

Alginates

These are substances derived from seaweed. They are colloidal in nature and swell in water. They improve the plasticity and unfired strength of claywares, and are also useful for doping glazes. Unfortunately they are more expensive than some other binders, and their use is therefore restricted.

Silicon Esters

For many years it has been known that compounds of the alcohols and silicic acid could be made—the so-called "silicon esters," or "silesters." Unlike the usual hard substances associated with silica compounds, these are colourless liquids with a characteristic smell. Ethyl silicate, which is typical of this class of substance, is a clear, colourless, inflammable liquid, boiling at 170° C., with a density similar to that of water. It is a compound of carbon, silicon, hydrogen, and oxygen, containing approximately 40 per cent. silica. Chemically it is not a particularly stable substance, and in the presence of water it decomposes into silicic acid and alcohol. This decomposition is called "hydrolysis," and it is upon this that its use depends. Silicic acid readily decomposes into silica and water, and it thus provides a means of depositing silica in another substance. The fact that silicic acid is formed as a gel with adhesive properties makes the hydrolysed ester a bonding material. Some of the esters can be hydrolysed by the use of water alone, but ethyl silicate requires the addition of a little methylated spirit as well. The gelatinous hydrolysed ester can be used as a bond for materials devoid of plasticity, and, after moulding, these can be fired to form a ceramic bond with the silica. It is claimed that, in this way ceramic shapes can be produced with greater dimensional accuracy than was formerly possible.

Applications of this method are the manufacture of low frequency porcelain, where the refractory material is added to the slurry of the hydrolysed ester, cast in a mould, and then fired to 1,250° C. This method gives great dimensional accuracy. Materials such as alumina, molochite, sillimanite, and zircon can be moulded successfully in this way, with the production of complex shapes, such as crucibles, burner blocks, etc. These are all fired at 1,250° C. after moulding, and it is claimed that the method avoids the costly firing to higher temperatures which have been necessary hitherto. A further application is to the production of moulds for precision casting of metals to tolerances of the order of 0·003.

Castings of this type, free from holes, etc., demands a high quality mould, and this is obtained by mixing sand or other grog with the slurry of the hydrolysed ester, and then casting it around a wax positive. After setting, this is melted out, and the cast heated to 1,000° C. The metal is then poured into the hot mould. The silicon esters are not cheap, and their use is therefore restricted to certain special applications, where the cost is justified.

Petroleum Waxes

The use of these for ceramic processes has been described by H. T. van Horn (8). The waxes may be made

into emulsions with water, and they have been used as binders for processing non-plastic bodies like steatite. It is also possible to use the dry waxes. R. L. Stone (4) found that for dust pressing certain types of electrical ware a mixture of 3 per cent. of a water-soluble binder with 3 per cent. of a petroleum wax product gave a body with better characteristics than when only a soluble binder was used. In these cases the body was granulated, and here the soluble binder gave good plastic strength in the mixture, to produce dust-free granules. When these are pressed dry the usual binders give no help to the green strength, but the wax does.

Waxes also act as lubricants in extrusion processes. Used in conjunction with an alginate van Horn states that most non-plastic materials can be extruded. He also states that wax emulsions can be added to glazes to give a smoother coating and to increase the strength of the unfired glaze so that losses by "knocking" are reduced. The emulsion also helps with glaze suspension, and does not migrate to the surface on drying.

Miscellaneous Binders

Various other binders and plasticisers have been described for special applications. A solution of rubber in xylene has been used for extruding fine refractory tubes and for shaping fused alumina. Mixtures containing bakelite resin have been used for pressure injection moulding of insulators. Articles made of magnesia have been extruded using cellulose acetate as a bond (Partridge and Lait [6]). Super duty refractories have been pressed using water soluble waxes or wax emulsions of the polyethylene glycol type. Phosphoric acid as a bond for zirconia refractories has been patented in the U.S.A.

Refractories bonded with a suitable material to give sufficient green strength can be built direct into the furnace without previous firing. They must contain a high percentage of fired grog, graded to give a high packing density, and are formed under high pressure. Magnesite, chrome, and fireclay bricks can be made in this way.

The avoidance of prefiring to high temperatures is an attractive feature of this method of building furnaces, and the results are sometimes better in service than when the traditional methods are used. The use of silicon esters in the preparation of sand moulds has already been noted. Other organic binders used for this purpose include resin, tar, and pitch. These are mixed with sand, moulded, and then baked at a low temperature to soften the binder. On cooling the setting of the binder gives the necessary strength. Vegetable oils, such as linseed oil, are also used. These harden by oxidation when the mould or core is baked. They have the advantage of not absorbing water when the mould is stored. Molasses, which turn to a sticky mass of caramel on baking, are also used as bonds for moulding sands and similar applications. The usual types of binders already described also find application in foundry practice.

Causes of Bonding

It finally remains to give a brief note on the causes of bonding. The purely chemical type of bond requires no further comment. McNamara and Comeforo (*loc. cit.*) postulate bonding between a liquid and a solid in two ways:—

(a) A mechanical bonding due to penetration of the liquid into a porous solid, and

(Continued on page 10.)

WELFARE IN THE HEAVY CERAMIC INDUSTRY

ON 8th March the Red Bank Cricket Club, Measham, will be holding its annual dinner in the Royal Hotel, Ashby-de-la-Zouche. The forty-three-odd members look back on a most successful season and remember their silver jubilee last year. The Red Bank Manufacturing Co. Ltd. began to operate the Measham works in 1920 and about four years later Mr. W. A. Lisney, the present managing director of the company, formed the club. It originated as a football club and then the cricket team was formed in 1927. Prizewinners for the 1949 season were as follows:

Batting Average: 1st XI, Mr. L. Wainright; 2nd XI, Mr. S. Pagett.

Bowling Average: 1st XI, Mr. W. Betteridge; 2nd XI, Mr. A. Jones.

Most Improved: 1st XI, Mr. R. Preston; 2nd XI, Mr. R. Perry.

ORGANIC BINDERS. (Continued from page 9.)

(b) Specific bonding due to interaction between the surface of a non-porous material and the adhesive.

In this case the necessary conditions for adhesion are the wetting of the surface, and the presence of certain active chemical groups in the binder, which are adsorbed on the surface of the material. In this connection such active groups as are found in the carbohydrates, proteins and gums are readily adsorbed on ceramic surfaces. The binding strength is roughly proportional to the length of the molecular chains the compound contains, and the water content of the body when the bond is formed.

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MR. W. DIETERICHS

IT is with the deepest regret that we announce the death of "Bill" Dieterichs.

The North Thames Gas Board has indeed lost a master craftsman with a flare for design and an ability to get things right largely based upon his

forty years' experience in the gas industry. He began as a gas fitter apprentice in 1910, and in the first world war rose to the rank of captain in the Royal Engineers. In 1927 he was in charge of the Gas Light and Coke's industrial gas workshops and was there during the development of industrial gas usage which took place in the years which were to follow. His work in this respect took him into the pottery and ceramic industries, paint and varnish making and applications; and in fact, wherever industrial gas is used, his name is an intrinsic part of many of the industrial appliances. In July, 1945, he was appointed manager of Watson House, and he retained this appointment under the new North Thames Gas Board.

On the day of his funeral the staff of Watson House arranged for a private service to be held in Watson House where so much of his work was done; and at the funeral service itself, representatives of associations and organisations connected with industrial gas were in attendance.

Mr. Dieterichs was 54 years of age, and probably no other name will be associated with the development of industrial gas usage to the extent that his was.

SHELL CHEMICALS LTD. announce that Mr. S. W. Farrington will be taking over their Scottish Division, whose office is at 28 St. Enoch Square, Glasgow, in succession to Mr. C. Duckworth, who becomes manager of their Midland Division, at King Edward House, New Street, Birmingham. Mr. Duckworth succeeds Mr. J. A. Porter, who is taking up a post at the head office of Shell Chemicals Ltd. in London.

Some of the new and experimental ranges of domestic pottery

Making Porcelain in South Africa

by

Colonel W. R. GORDON, O.B.E.
Member of the Institute of Industrial Administration

AT the present time there are only three factories in the Union making medium voltage and refractory insulators. One of these, the South African Glazing Co. (Pty.) Ltd., of Boksburg in the Transvaal, only began operations 5 years ago but has had, and continues to enjoy remarkably swift development. Within the last 4 years the factory area has quadrupled. Starting with the manufacture of over 250 different types of insulators, the firm is now branching out into the art pottery field.

This expansion has been all the more remarkable when it is realised that, with a total white population of only two and a half million in the Union, the market for any one particular line is extremely small. In the older industralised countries it may be possible for a ceramics manufacturer to specialise on a few lines which he can produce in mass quantities and which will ensure his production for some years ahead. Here, in South Africa, on the other hand, the producer has to earn his profits from making a large number of lines, each of which can only have a very limited run.

Range of Products

Perhaps for this very reason the range manufactured by S.A. Glazing Co. (Pty.) Ltd. has an especial interest. Among the wide number of lines made are porcelain for all the four

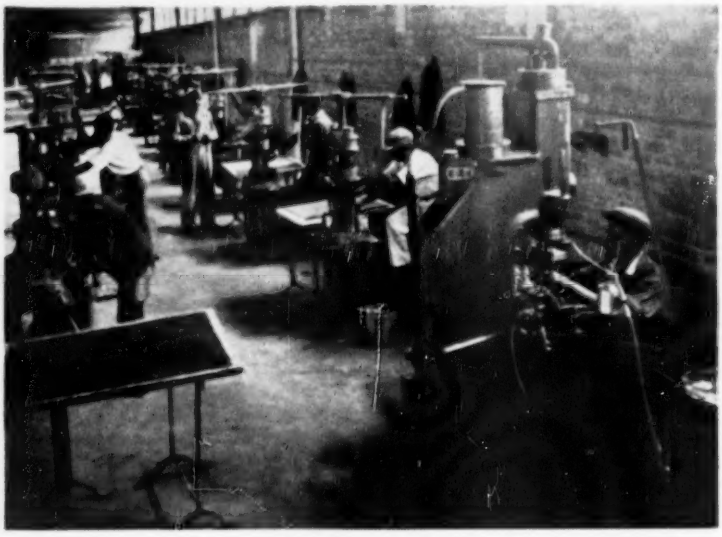
stove manufacturers in the country and for hot water geysers; combustion boats for testing steel charges, for sulphur content, carbon, etc., just before charging into steel furnaces; porcelain for the switches now being made by J. A. Crabtree (S. A.) (Pty.) Ltd. at Springs; fuse bases; flying fuses; bobbins and cleats for ceiling wiring; line insulators, e.g. pins and shackles for overhead and low tension transmission; all kinds of bus bar insulators; electric radiator bars; elements for electric water heaters and so forth. In building up their business the three partners, two of whom are Hollanders and one of whom is a South African, have worked on the principle that no single enquiry should be neglected and that no order is too small.

Availability of Materials

So far as raw materials are concerned 97½ per cent. are of South African origin. The various clays, silica, felspar, etc., are mostly obtainable from sources in the Transvaal. The firm, too, makes its own glaze. But, in siting the factory, the partners have elected deliberately to situate it close to the largest actual and potential markets in the Union. This policy means that, while the raw materials have to be transported to the factory the finished article can be delivered only short distances by the firm's own transport.

The labour employed is mostly Native, there being some 130 Natives to 25 Europeans. But, while the Natives are very good at hard, repetitive work, they need close supervision and take some time to train. They work best when they are given jobs which are always similar and where little or no initiative is needed. Many of the Native employees are Shangaans from the northern and eastern Transvaal. They prove to be clean workers and are adaptable to machines.

In the manufacturing processes the raw clay and other materials are delivered already ground from the mills. They are then weighed and mixed, passing from the mixer through first a screen and then through a magnet to remove all the metal present. From there the raw clay is taken to the edge runners, where water is mixed so as to obtain an intimate mixture of water and clay. Thence the clay is taken to a de-airing pug mill, where all the air is removed and where it is extruded in the required shape. Thus the clay is ready for the presses, pottery whisks, or lathes and ready for processing. Next it is dried and fettled and biscuited or glazed, before firing. Due



The press room

The packing room and dispatch department

to the fact that, when the factory started up in 1945 there were no suitable machines, many of these have been constructed in the works themselves. The de-airing pug mill, in fact, is of an improved type designed by the company's own engineers. Now, however, with the improvement in the supply position, some new British machinery has been imported and installed. These new machines include four Denver agitators, a Manor filter press and pump, as well as a Blencut three deck vibratory sieve and electro-magnet.

Firing and Fuel Consumption

The oil-fired tunnel kiln, erected by the firm itself, it 140 ft. long and the most modern of its kind in the Union. Temperatures, which are carefully controlled by pyrometer, vary from atmospheric at both ends of the kiln to 1,300° C. in the centre. Altogether over one million articles are fired every month. Fuel consumption is, approximately 220 gallons per 24 hrs. and the cost 1s. 7½d. per gallon delivered.

After firing, the articles pass to the packing and sorting room. All the operations, which for any particular line may number as many as ten, are carefully supervised and inspected to ensure a reliable quality of final product. The firm has its own die shop for making all its own metal dies and has, in fact, evolved a new technique in die making. The moulds for casting of course are of plaster of paris. Glazing is done both by spray and by dipping, though the former is favoured more and more because of the more even finish which it gives.

A good deal of constructional work is in progress now. Not only is there a new clay mixing plant being erected, but also change houses and dining rooms for both European and Native staff. Indeed throughout the spectacular expansion of this firm, during the past 5 years, fresh building has inevitably, been almost continuous. Such rapid development has, without doubt, brought its own literal "growing pains."

An up-to-date costing system has been installed and the firm claims to be able to calculate its costs for any particular process or article to a hundredth part of a penny.

Art Pottery

In due course S.A. Glazing intend to enter the high tension field, where prices are better and where there is a good market. But the next line of development is the production of art pottery. In October 1949 the output of vases and ornamental ware began.

It is intended in due course, to make art tea sets and occasional pieces, such as butter and cheese dishes. Only the small size of the market prevents the installation of the necessary machinery with which to turn out ordinary crockery.

Another line, for which there is a small but steady demand, is that of a Native charm. This is worn by the Shangaans either in the hair or round the neck on a string. It is believed, by those who wear it, to ward off all illnesses. So strong is this belief that a simply moulded piece of porcelain, scarcely more than 1 in. in diameter, is sold retail in the Native shops for 2s., quite a lot for a Native to spend.

A Dutch artist who formerly painted pottery in Holland, is employed. The turning of the art pottery is done by an Italian workman, formerly a prisoner of war in the Union. The colour glazes are all done by the firm themselves. Through the accidental discovery of the boyhood talent of a Native workman, quite an extensive range of animals, such as giraffe, buck, camels, dogs and the like is being created. All these new lines will be displayed at the forthcoming Rand Easter Show.

Industrial Trend

This factory is a most interesting illustration of the striking by rapid developments towards industrial self-sufficiency going ahead in South Africa today. At the same time it indicates a great deal of clever improvisation, necessarily brought into play due to the lack of existing equipment of the type needed within the country, during the last four post-war years. If this firm had waited until machinery could be purchased from overseas, no doubt it would not be in production yet. But, by ingenious design and construction from raw materials on the spot, a plant has been built up fully capable, as it expands still further, of meeting the demands of a growing market. It is a tribute to the results of progressive, energetic and capable management.

A CHASESIDE MECHANICAL SHOVEL USED BY THE CLAY INDUSTRY

THE Chaseside Engineering Co. Ltd., Station Works, Hertford, Herts, have given us information on their mechanical shovel, which is being used in a number of brick and tile works. The illustrations opposite show the equipment being used in handling clay.

Normally it is recommended that the ¾ c. yd. machine with a special slotted scoop fitted with three teeth should be used. The slots reduce surface adhesion and facilitate discharge of the somewhat sticky material from the scoop, preventing the build up of a layer of material, which restricts the output of the machine.

There are two main uses for the shovel by the clay industry, namely for digging the clay from the face where the situation of the clay pit itself permits, and also for stock piling work which operation may be done either when the machine is not working at the face or alternatively if conditions do not permit of work at the face, then it can frequently be employed exclusively on stock piling. It is known that any wheeled machine is restricted in waterlogged conditions, yet the illustrations represent fairly average conditions encountered in use.

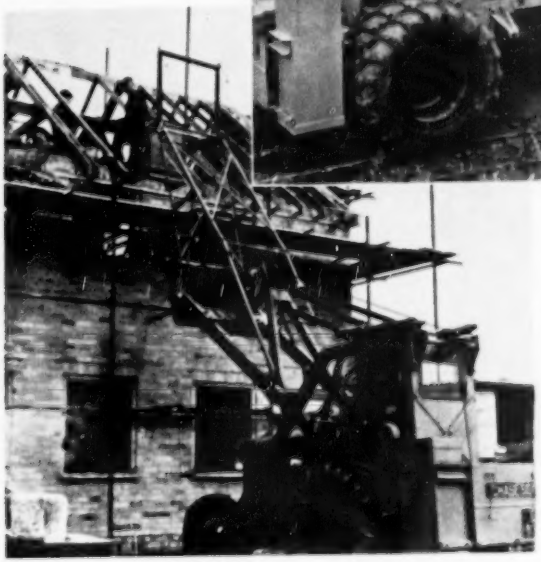
The Chaseside Shovel has a comparatively low purchase price, as low as about £700, and a low operating cost, including maintenance and fuel oil.

The dumper used with the shovel is also a low priced machine, and is able to operate satisfactorily over difficult ground conditions. For site work where perhaps there is a long or comparatively long haul from clay pit to stock pile, or works, this particular item of equipment is quite an economical means of dealing with the problem of transporting the material.

Naturally, however, both the dumper and the shovel depend for their employment on the situation and layout of the clay pit.

(Left) Chaseside shovel in use under adverse conditions

(Right) The shovel working in conjunction with the dumper



(Left) Chaseside brick-stacker attachment with maximum output of 3,000 bricks on to a 16 ft. high scaffolding in one hour

Some Aspects of Standard Costing in the Pottery Factory

by

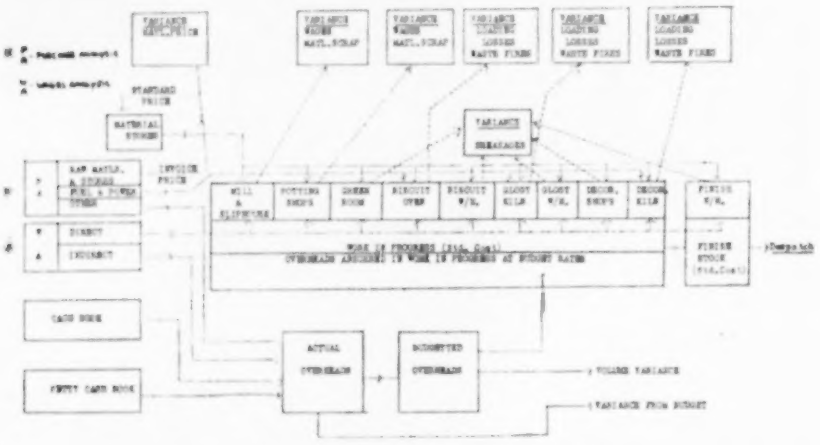
E. H. A. WHEEN, A.C.A.

A report of a paper presented to the Sub-Branch of the Institute of Cost and Works Accountants at a recent meeting held in Stoke-on-Trent.

A SYSTEM of standard costing has been devised whereby aid can be given to management of all grades by means of cost accounts and cost information, in addition to producing individual costs for fixing selling prices and the necessary information for the financial accounts.

The accuracy of the cost information is assured, as it is completely integrated with the financial accounts and the same information is used to produce both sets of figures, from one specially designed nominal ledger.

As this subject covers a very wide field, a great deal of which concerns only the accountant, this paper is intended to deal with some of the aspects of standard costing, and in particular, those affecting the managers and persons who use and provide information to compile the standard costs. The type of factory envisaged in this article is one which is producing useful and ornamental bone china ware, but in general, the principles can be applied to any type of pottery factory.



A standard costing chart for the pottery industry

Standard Costs

Pre-determined or "standard" costs are built up for all the elements of cost which give the total cost of the articles concerned. These standards are maintained until some change in values occurs and it is considered necessary to alter the standard costs; usually it is not desirable to make too frequent changes in standards and it is suggested they should be reviewed once a year.

Where levels of production affect the cost, it must be decided at the highest level of management whether the standard cost is to be based on a maximum theoretical output or on a normal level of performance in the shops. The latter method is preferable because it gives a fairer view of the cost and when summaries are produced showing the results of actual performance against the standard performance, the managers concerned with production from the shops would not be discouraged as would be the case if they found their production failed to reach the high theoretical output which would be required by the former method.

These standard costs are used to obtain the standard value of production at the different stages in order to compare with the actual value at the same stages. The differences in these values are termed "variances" and it is the analysis of these variances that should be submitted to the management.

Compilation of Standard Costs

(a) *Cost Centres.*

In order to build up the standard costs of the various articles produced it is necessary to determine cost centres or process stages at which control information on costs and production can be obtained, and costs will be built up to give totals of costs at these stages. Furthermore the accounting analysis in the financial books will be so arranged that the actual costs at these stages can be readily ascertained for comparison with the standard costs and disclose any variances that may exist.

The following list of cost centres together with the cost information for which standards must be set, will show the build up of the total standard cost:—

1. *Cost centre*	Mill and sliphouse
Cost elements ...	Raw materials
	Labour
2. *Cost centre*	Green room
Cost elements ...	Potting wages
	Mould-making wages
	Mould-making materials
3. *Cost centre*	Biscuit warehouse
Cost elements ...	Biscuit oven fuel
	„ „ wages—placing
	drawing
	firing
	„ „ materials
	Biscuit warehouse wages
	„ „ materials
4. *Cost centre*	Glost warehouse
Cost elements ...	Glost kiln power
	„ „ wages—placing
	drawing
	firing
	„ „ materials
5. *Cost centre*	Finished warehouse
Cost elements ...	Decorating wages
	„ materials
	„ kiln wages
	„ „ materials
	„ „ power

(b) *Cost Data.*

The cost centres having been decided upon, the next step is to compile the data required to calculate the standards for inclusion in the standard cost cards. It should be noted here that all production and cost data taken from the factory should be approved by the various managers and it should be understood that the information they are supplying will form the basis of the standard costs and be used in the various cost control schedules. It is vital that the managers appreciate this and their co-operation is of the utmost importance.

1. Raw Materials

All raw materials used in bodies, glazes, saggar mixes, and in the kilns and ovens should be listed and the price obtained from the purchasing department—such prices to include the cost of delivery to the factory. After allowing for the possibility of any increase or decrease these prices then become the standard prices to be used in the costs.

The formulæ for the body, glaze and saggar mixes should be obtained and the quantities of the various raw materials valued at the standard prices. From this valuation it will be possible to arrive at a cost of say, 100 lb. of each mix, and although this unit of weight will be a wet weight, the cost of the raw materials will be the value of dry materials contained in that weight. In assessing the value of the weight unit, an allowance must be made for scrap materials actually lost; this allowance does not include scrap clay returned from the potting shops for re-processing.

Other materials that are included in the prime cost of the articles, such as alumina for placing in the biscuit ovens or kiln furniture used in continuous kilns, will be assessed at an appropriate standard cost and will be included in the unit of cost to which they relate. Similarly where decorations are applied to ware, standard charges will have to be determined for colours and precious metals.

2. Labour

For body and saggar mixes a standard labour cost for a definite weight unit (say 100 lb.) will require to be established in order to include the appropriate labour charge in the standard cost card. In building up firing costs for ovens and kilns, again standard labour costs will require to be established for each oven with intermittent ovens and on a basis of a set period of time for continuous kilns. Further data required will be the piece-work prices paid for each of the potting and decorating processes; where no piece-work prices are available estimates must be made as it will be necessary to make out a standard cost card for each article.

3. Fuel and Power

In order to include the appropriate charge in the standard firing costs of the ovens and kilns, it will be necessary to calculate the tonnage of fuel used in intermittent ovens and the units of gas or electricity used by continuous kilns. Once the usage of fuel and power has been established, a standard cost can be calculated by valuing the unit of usage by the standard price of the unit, and the standard values of consumption when compared with the actual value will give the variance.

4. Cost of Firing

In charging the cost of firing to the individual pieces, there are three factors to be dealt with:—

(a) *Spread of the Firing Cost to Articles.* With intermittent ovens the space available in the oven is constant and thus will be filled with an approximately constant volume of saggars. Counts can be made to find out the average number of each type of saggar used to give a normal fill. One particular saggar, preferably the one most used, is taken as the standard saggar and allotted 100 points. A points value for all other types of saggars is then calculated by relating the volume of each saggar to the volume of the standard saggar. By valuing several saggar counts for an oven, a total points value for one oven can be ascertained and an average total points value calculated. Only those saggars which normally carry ware are calculated, and others, such as soft fired saggars fired at the top of the oven and not carrying ware, are not required in the counting

of points. By taking details of how the various pieces of ware are placed in the saggars, the points values of the saggars can be transferred to the ware. To make the charge at standard cost for the firing of each article, the firing cost must be spread over a standard number of points for each oven; this standard level will be set at a figure which is considered a practical fill for each oven. Each article now having a points value and the standard cost of each point having been determined, it should be possible to calculate the standard cost of firing for each article.

With continuous kilns the procedure is slightly different; each truck is given a nominal number of points, say 1,000, and a count is made to see how many, of a particular article can be placed on a truck. This number is divided into 1,000 to give a points value for the particular article. The total standard number of points must be set in order to spread the standard cost of firing and arrive at the cost per point. The cost of firing is then charged to the standard cost card according to the points value of each article.

(b) *Waste Fires.* The standard cost card represents the cost of a good piece of ware, and the firing cost included on the card, according to the points value, represents the cost of firing one good piece, and that good piece must carry the losses incurred during the firing processes. Each time a piece of ware is rejected after firing, either because it requires re-firing or is a total loss, there occurs a firing loss which must be charged back to the cost of the good ware. Thus out of a total number of points fired, a certain number will be points for good ware fired and the remainder for bad ware fired—these latter representing the waste fires and which can be related to the good fires and expressed as a percentage for use in the cost cards. Tests will have to be made and standard percentages set to cover these waste fires. Different types of ware will have different losses in the ovens and kilns and it will probably be necessary to divide the products into sections, each of which will have a different standard waste fire percentage.

(c) *Kiln Losses.* The third factor to be considered is the cost of the loss of the piece of ware that is rejected. The whole of the firing cost has been dealt with and it is only that value of the piece to the process stage before firing which requires to be considered. Again the standard cost card represents the cost of a good piece and the losses must be carried by that good piece—tests will have to be made to find the relation of the pieces lost to the pieces good and an allowance made on the cost card to cover this loss. Here again the products will require to be divided into groups (similar groups as for the Waste Fires) and standard percentages set for each group.

5. Clay Weights of Articles

As described previously, a standard cost of materials and labour for a unit weight of clay (say 100 lb.) has been determined. In order to charge to the cost card the value of the clay in any particular article it will be necessary to know the weight in clay of that article. The dry clay weight (as in the green room) of each article should be obtained and from these figures the standard cost of the clay in each article can be calculated.

(d) *Overheads and their Application.* It will be found that overhead costs form a large part of the total cost of the article and therefore this portion of the cost is extremely important. Whereas the prime cost elements are mainly under the control of managers, only portions of the overhead charges can be said to come under departmental control. Thus overheads can be grouped in two divisions, those for which managers can be held responsible, such as all shop, departmental and factory wages and expenses, and those which come under the control of the Managing Director or Factory Manager, such as administration, selling and research expenses.

The latter overhead items will be suitably grouped and analysed for control purposes and charged in the cost cards by a percentage on prime cost, or related by a percentage to the labour content of the article and charged in that manner. The shop, departmental and factory overheads will be analysed to their appropriate sections and schedules prepared giving

an analysis of these charges for review by the managers for possible economies in expenditure. If budgets for overheads have been prepared the schedules will show the budgetted figures as well as actual expenditure and differences can be examined. These overheads will then be charged in the cost card at the budget rate, calculated on one of the above-mentioned methods.

Where it is not possible to analyse overhead expenditure to processes, it is analysed to departmental and factory expenditure and charged in bulk on the total cost of the article. Again the actual application may be based on the total prime cost or the labour content of the article, but whichever method is used, the accounts department will calculate all overheads absorbed by production and goods sold, at the rates used, in order to compare this figure with the actual expenditure of overheads.

Cost Controls

The various standards for material prices, wages and firing cost factors having been determined and the standard cost cards prepared from this information, it will be understood that production, process by process will be valued at these standard costs, and differences from these standards shown as variances in the operating statement prepared by the accounts department at regular intervals. These variances will be gains and losses and will arise in each of the cost centres previously described. The managers of departments will wish to see the performance of their departments measured in terms of money at the standard costs, and to know what variances exist, particularly the loss variance in order that these can be examined and if possible eliminated.

Control schedules can be prepared for each cost centre and even for sections within a centre. The management of the factory should decide what are the important factors to be controlled and the cost department prepares the control schedules for circulation to the appropriate managers, whose responsibility it is to take any necessary action to rectify unsatisfactory results. The accountant at his discretion will raise, through the proper channels, any other queries affecting variances or excesses.

The most important controls are the control schedules for the ovens and kilns and the departmental overheads where a complete analysis is made. The firing control sheets show variances caused by variations in the total amount of ware fired, waste fires and kiln losses, and the overhead controls will show the variations in expenditure, and excesses or otherwise over budgets, where these are used.

The master control is the operating statement prepared for the higher management level. This shows the standard cost of each stage of production, together with associated variances, the adjustment for work in progress, the standard and actual profits or losses produced on output during the accounting period, and the sales for the period.

Uses of Standard Costing

The uses and advantages of this system of costing and accounting are summarised as follows:—

(a) There is an automatic and complete integration of the cost accounts and the financial accounts.

(b) Regular information is provided in considerable detail of the performance of the production departments.

(c) Losses and inefficiencies can be readily traced.

(d) Overhead expenditure can be controlled.

(e) Regular operating statements can be produced showing profits and losses by departments.

(f) Individual costs can be prepared and used to fix selling prices.

So far as standard costing is concerned, the function of the accounts department, which includes the cost section, is to carry out the work necessary to produce all the standard costs, assess the information collected from the production departments at these standard values, to co-ordinate this work with the actual values and to prepare the various statements previously mentioned.

In order to carry out this work quickly and efficiently there must be close co-operation between the accounts department and all the production departments.

A view of a glazing shop—a difficult heating problem

Space Heating

A Problem in the Ceramics Industry

THERE are many instances of buildings which do not require to be heated to a uniform temperature for 24 hours a day. Furthermore, there are in addition, many space heating requirements in which comfortable working conditions for the operator are more important than a high uniform temperature in the room itself.

If an effort is made to heat a workshop or canteen, or even a church, by central heating, using the principles of convection, then comfort is only realised by the occupants when the temperature throughout the room in question is raised to that which is the comfortable temperature for the operator or the occupant.

As soon as this problem is considered, fuel usage becomes a primary consideration. Adequate heat insulation of the building is the biggest factor in conserving fuel usage when convected heat is the heating medium employed. This sometimes is expensive or impracticable.

Difficult Proposition.

The ceramic industry presents quite a difficult proposition in so far as heating for the comfort of operators. Typical instances of such difficulties mentioned at random include mill rooms, slip houses and in fact, wherever there are large masses of "cold" fired clay products which have to be handled. Add to this the continuous and necessary opening and closing of doors, as well as the humidity of the atmosphere, and probably of all means of heating, overhead Radiant Heat panels offer the most flexible approach. Luminous panels, in particular, emit their radiant heat and have the psychological advantage of "looking warm."

Radiant or Convected Heat

The question of whether or not

radiant or convected heat is used as a medium of space heating is controlled by the dimensions of the building and sometimes by the number of hours per day which the building is occupied. In some types of buildings where the dimensions make it impossible to site overhead radiant panels, and the processing carried on make the use of high temperature services undesirable, a system of heating solely by convection is often the best answer, but in the case of large factory layouts with doors opening and closing, then radiant heat offers an excellent contribution. The advantage of thermostatic control should be considered.

Furthermore, with a convected heat system, draughts reduce its effectiveness considerably, making it an extremely expensive medium of heating where frequent atmospheric changes of air are necessary, such as in the case of public buildings, schools and hospitals.

Intermittent Use

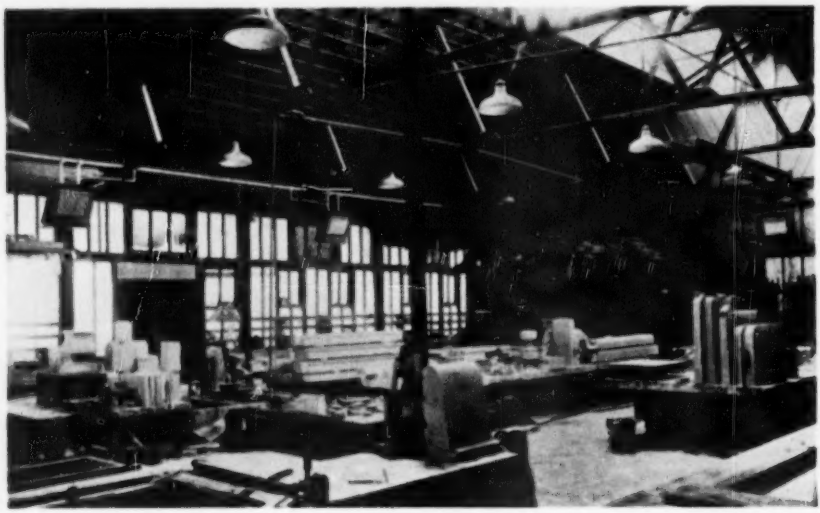
In addition, it must be remembered when considering a space heating installation that it becomes a necessity in the six or so winter months of the year, but is often completely forgotten for another six months.

In other words space heating, as far as the British Isles are concerned, is discontinuous, in so far as it is used for approximately six months of the year only, and in a specific location it may be discontinuous to the extent of being used only eight hours a day or, in the case of churches, canteens and public buildings, an even lesser number of hours per day.

A convected heat installation requires time before the temperature of the atmosphere is raised to that degree necessary to give comfort.

On the other hand, using radiant heat, it is possible to project the heat rays directly on to the occupant of the room so that the heat energy is absorbed by the occupant. Constantly these heat rays are coming in contact with the floor, which has its temperature raised by the likewise absorption of heat energy, after which of course, convection from the heated surface begins to play its part.

It is not necessary to have the installation operating a considerable time before the room is occupied. It is possible to have an open window and yet for the room occupant to be quite comfortably warm, providing there is no direct draught on him.



Showing the interior of a stonemason's works. A difficult heating installation, as the chill from the stonework is in itself cooling

Mystical Powers of "Infra-Red"

Although much has been talked in recent years of the somewhat mystical powers of "infra-red" which, of course, is the heat portion of the invisible spectrum from the sun, yet it is not new. The sun has been heating the earth and its peoples for millions of years by direct radiation. It is only when the sun disappears over the horizon that night and corresponding cooling is noticeable. In winter, when the radiant heat rays from the sun strike the earth at an acute angle, the amount of radiant heat transmitted is reduced.

Therefore, to the person contemplating the installation of a space heating appliance, certain factors should come up for his consideration. He should ask himself:

1. Is the thermal insulation of the room in question likely to be difficult?
2. Will draughts present a problem?
3. Are the surroundings likely to be "cold" in the form of concrete and stone?
4. Is the heating required intermittently?
5. Is it possible to select the part of the room where the occupants are seated and warm them to the exclusion of corridors not so occupied?

Advantages of Radiant Space Heating

If he can answer in the affirmative to these questions then a radiant heat installation in the form of overhead panels or wall panels is a distinct probability. If he can employ radiant space heating, then the following advantages accrue:

1. He has a considerably lower initial capital cost.
2. He can conserve fuel by using the installations intermittently as required.
3. He can save fuel because by not raising the temperature of the whole room to comfort heat, he minimises the conduction losses through the walls and ceilings.

Radiant space heating is not the answer to every heating problem, but quite obviously it has many applications, and where it is possible to make use of this heating medium, in the interests of fuel economy alone, it should be very carefully considered.

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THE CHALLENGE *and the* RESPONSE

by CUTHBERT BAILEY
(Director, Royal Doulton Pottery)

IT is generally agreed that the destructive power man now has at his command is so great that the continued existence of our civilisation depends on the elimination of conflict as a method of settling national differences.

If that is so on the international stage, it is no less true in the industrial setting. So it is indeed unfortunate that to the complexities and strain inflicted on our age by warfare, with all its consequent economic weakness, our nation is inflicting on itself the strain of a developing national discord while it painfully adjusts itself to the growth of a new industrial order.

History Proves

Now, as historians record, one of the perennial infirmities of human beings is to ascribe their own failure to meet the challenge of difficulty and adversity to forces that are beyond their control. But, if history proves anything it proves to the satisfaction of thinking men that the breakdown of civilisation is not brought about by the operation of cosmic forces outside human control. Other causes have to be found for either the progressive disintegration or the catastrophic collapse of the fourteen civilisations that have preceded our time since history was recorded. "Society," writes Professor Toynbee, "unlike the individual, does not ever die from natural causes, but from either murder or suicide—and nearly always the latter." From the fall of Babylon, Carthage and Rome to the fall of China in our current age, the corridors of time are one vast labyrinth of succeeding dynasties which have risen, swayed, tottered and fallen. It was so, it is so, and we must assume it always will be so!

So let us look for a moment into why it was so, why it is so, and why—on all historical evidence—it always will be so. Why do nations, kingdoms, empires, rise to great proportions and eminence and then, gradually or otherwise, "Flit russetly away"? The answer appears to be twofold: a weakening disposition to meet the challenge of the time; and the loss of wealth. Now wealth may be described as the crystallised surplus of the initiative, enterprise and labour of yesterday available for the strength and service of today. For it is the acquirement of wealth in the first place which enables a nation to rise, and it is the loss of wealth in the first place which results in a country falling. Rich nations rise; poor nations are in grave danger of falling. Our national financial reserves were cleared out by the war; that raised a crisis that requires no explanation, and certainly needs no apology. But it has had two consequences; it has sapped our national strength, and it has left us a nation (whose previous career had been so full of movement and meaning) lingering on divided and somewhat inert and halting. That is our danger, for our nation is now subject to one of the greatest and most urgent challenges of its long history—the challenge to recover from almost mortal financial weakness, to end industrial strife and class conflict, and to put its house in order while there is time. And it does not seem possible to me that Britain will be afforded many more chances to save herself by her own efforts.

A Challenge

Every event in life, to a society, and to civilisation itself, is a challenge, and the future in some measure, either in small, major or mortal degree, is affected by the response.

The proposal to give this paper to your association was a challenge, both to accept, and to find a way possibly to be helpful and avoid being unduly provocative. It will be clear, I trust, that the views I shall express in the pages that follow must represent, at any rate at this stage, the personal reflections of myself and of no one else.

History, while always valuable as a guide, can tell us nothing positive, and each generation must explore for itself its own way of travel. Immunity from the encounter with difficulties is never present in any age. The most serious handicap is *apathy*, a Greek word which came to signify

insensibility to the pains of experience, or, in other words, indifference to the stimulus of challenge. No age can rest on its oars. What history does demonstrate is that it is never safe to relax.

So much as a brief background to our review.

Two Conceptions

There are emerging two conceptions of Socialism, and in some ways they conflict. The official doctrine is confident and assured; the other is less confident but is increasing in its assurance. The first rose to power because it based its appeal on the promise to make life easier and more secure for the masses. But now that official doctrine has reached a new stage. Sir Stafford Cripps insisted—both in his Budget Speech and again at the Blackpool Conference—that any extensions of the social services, or any general rise in the standard of living, *must be earned*. More benefits, he said, can only come from higher production—and even those cannot be guaranteed, for we shall be hard pressed to maintain present standards and pay for essential imports when American aid runs out.

At the same time the voice of the other Socialism is heard. It is expressed partly in complaints, partly in rather vague aspirations and assertions. It speaks of "a wide sense of frustration"; and of "being held down by management," and moves towards "workers' control." This Socialism conflicts sharply with the official brand, which insists that the running of industries is a job for experts; that "managerial jobs can only be done by managers"; and that workers cannot be directly represented on the industrial Boards, for managers and workers are on different sides of the fence.

Usually workers' participation is portrayed as a demand that workers in a firm or industry should select representatives from among themselves, either to take "control" (and in this crude form the demand is on every count absurd), or to take a share in the task of management.

Workers Share in Management

Now, while it is true that management is an expert job and that the man best qualified for it, by training and ability, should be appointed to do it, yet the demand may represent a very real and justifiable desire by the workers to be treated as responsible collaborators in the enterprise they serve, and not merely as hired hands. This is a desire that can be met, and by now many firms have, in fact, gone a long way to meet it, by conveying information in factory bulletins and by discussing matters of importance through joint consultation committees. And many decide to relate higher reward to higher output—which, as Sir Stafford Cripps says repeatedly, is all the country can now afford.

So far, much more progress with these new methods has been made by private firms than in the nationalised industries. So much so that the Government now regards one of its most urgent domestic tasks to be the arousing of a new spirit of co-operation in the industries already publicly owned. And it appears equally clear that a section of the workers in those industries are countering by declaring that the reality behind any new spirit of co-operation should be an increasing share in the management. If that demand develops in the nationalised industries, then we are likely to hear more and more demands that workers should have a more responsible share in the management of industry in general. But dreams and sincere intentions have often little relation to realisable achievements. Sir Stafford's statement that workers' control was not possible even if it was desirable did not mean that no workers had the intelligence and initiative necessary for a share in management. He meant that if industry was to be efficiently managed, appointment must be on the grounds of competence and not on grounds of representation. He meant that very few of the workers had the necessary training and experience; and that whatever the human faculty or the sphere of its exercise may be, the presumption that, because a faculty has proved equal to the accomplishment of a limited task within its proper field it may therefore be counted upon to produce a notable effect in a different set of circumstances, rarely leads to anything but disaster. And in that statement he would, I suggest to you, also be conscious of the growing evidence of the fact that trade union officials sitting on governing boards, e.g. the National Dock Labour Board, have widened the gulf between them and the rank and file. The reason for this appears to be that the leader who was once their spokesman has somehow become their employer, and not pledged to support them. This has led the workers (still paradoxically holding to the principle of Joint Control!) to begin to look for other leaders clearly distinct from those who have become their employer, and no longer pledged to support them. And so the new machinery, instituted with so much hope, breaks down because the workers' representatives are, in their turn, merged in that great amorphous "they"—the Managers.

Is not this in itself dangerous: evidence that workers' representatives are expected by the workers themselves to follow a partisan rather than an industrial course, and that if power passes to an industrial caucus, governed by political and narrow motives, the mainspring guiding industrial policy may tend also to pass from national health and welfare to class advantage? I

refrain from any generalisation; I merely point the evidence and ask the question.

One-Sided Outlook

An intimate knowledge of working conditions from the workers' side may qualify a man for the welfare side of control and for the art of what is horribly called "man-management," but it hardly qualifies him for the technical handling of industry. The large and small decisions which a management must take often demand immediate decisions by those possessing specialised knowledge and long experience. It follows that men who come late to the problem of management are little likely to make a success of it. Moreover, a lengthy experience of trade union negotiations may be a handicap, in some respects, for it may create a habit of looking at a technical problem from only one side.

If workers are to have an effective share in control, they must be prepared to see their representatives adopted and trained wher young. That will not be easy to arran_e, but it is difficult to see any other useful way. There is no good reason why the trade unions should not co-operate with management in arranging for courses of study for their keener members, so that they may learn to see all round the problems of the business that employs them, and understand the complexities and anxieties of running a modern commercial concern. Among those who showed the quickest grasp and surest understanding, there might be found the most suitable aspirants for managerial training. Old-fashioned firms would not like this, nor would old-fashioned unions, but that would constitute an approach that might be tried.

But these new managers would have to learn more than new habits of mind. They would have to learn to assume responsibility for the welfare of the whole concern. They would have to accept the principle that capital investment must be provided for the benefit of all. They would have to rid their minds of the sentimental humbug that all profit is wrung from the sweat of the toiler, and recognise that if it were not for investors seeking profit the toiler would be sweating a great deal more. They would have to admit, for example, that a lightning strike is quite simply a breach of contract, and as such treachery to the country, the unions, and to all honest trade unionists.

Further, an able and conscientious manager of an industry's interests must be prepared to risk unpopularity among the shareholders from time to time. Similarly, a manager nominated by the workers would have to risk unpopularity among the workers. He would have to know that managers have to do a managerial job and in that capacity may have to resist demands from the workers. He must be prepared to do that, worker though he has been himself. An official promoted from the ranks cannot afford to take up the attitude of defending everything that is thought and done in the ranks. He must accept the responsibility of his part. So must the worker who seeks to share in control. Too many experiments in some share of management have failed for this very reason. The workers' representatives could not bring themselves to admit that the workers could ever be wrong. That was called loyalty, and loyalty is a fine thing. But loyalty that is one-sided, partisan and uncandid is merely bigotry under another name, and bigotry is not a fine thing.

When workers ask for a share of control they are asking for a share of power. But power cannot be taken without responsibility, which is often difficult and sometimes unpleasant. Workers claiming to share in control are claiming to rise above their own particular and immediate interests, and above their natural prejudices. That is not an easy thing to do, but it is the thing that must be done. For, if this country is to possess power of recovery from its prevailing difficulties it is essential that the aim must not be the ambitions of the individual or the eminence of a class, but the stability of the community. A nation such as ours is palpably in process of disintegration if the fabric of our civilisation be undermined by the interests of the individual being regarded as a supreme aim in life.

Discard Ideologies

Before I pass on from this particular issue may I add some further personal reflections. If man's wisdom and understanding advanced with his ability and capacity, then, with all our political and economic knowledge, it would be easy to judge in what measure strength can come out of our present weakness, and what new form of world and industrial order should come out of our present chaos. Man's wisdom and understanding has not so advanced. Nevertheless, some people appear to think that certain vague principles have only to become airborne—such as "joint industrial management"—to be found worthy of a wide measure of support. The impact of a word or a new industrial slogan can inspire men not only with enthusiasm but with a kind of conviction, although it tells them nothing of that trained and careful scrutiny of events and rational analysis which modern industry demands. And bitter experience has often demonstrated that it is dangerous to attempt thus to simplify problems of singular complexity. So, intending malice to none, let me be blunt and put certain cards on the table. Where there are greedy and

self-seeking men about (and unfortunately there always will be), to whatever class they belong, it is much better that they should possess the very limited power of private workers or private business men, and not the vastly greater powers of officials and politicians.

If man were nothing more than an economic man, actuated by motives of mutual security and interest, there would be little reason for their colliding with one another. But, unfortunately, man is a political as well as an economic animal. He wants to contend with not only human needs and economic problems but also with ideologies. But, I suggest, what the world needs at this time above almost all other issues, is to get the issue of free enterprise versus Socialism off its ideological pedestal, and to treat it, not as a matter of semi-religious faith and fanaticism, but as a commonsense and practical question. The future of this country—if it is going to have a future—depends on our finding our bearings in this matter, and a clearer conception of man's duty to man and to his country.

Unteachability of Mankind

"Joint Industrial Management" would be progress only if these new custodians of their country's destiny showed the most serious consciousness of their responsibility, and evidence that they desired to employ the exercise of power towards ends nationally and socially desirable in the widest possible sense. On the other side of the picture, social man, man in society, if actuated by politics, ideologies and sectional greed, courts disaster at a rate so rapid that his annihilation becomes a matter of where next he plants his reckless step, and how much he learns to think in the few years left to him to find salvation. Small wonder that Winston Churchill speaks somewhere about "the confirmed unteachability of mankind." The seeds sown by the activities of innumerable individuals are various. The seeds sown are separate seeds, and each seed has its own different destiny. But let the seeds be of the best kind, and sown in the hope of a fruitful harvest, then it will be clear that the aim *is not* "the ambitions of the individual or the interests of a class, but the health and stability of the community." Gentlemen, conflict is death to industry; and British industry in particular will only be able to make its way if there is unity of purpose towards common interests and benefits.

If what I have said is a reasonably accurate assessment of a general view on this developing challenge, are there further reflections that many would desire to add? I am sure that there are, and in what follows will venture to speculate on some of them.

It is perhaps true to say that every epoch has its characteristic excess which produces a violent reaction in the succeeding generations, and that this is as true of industry, as of society, for which industry forms the breadwinner.

Industry's Record

The excess I now refer to was the autocratic regime that controlled development throughout the last century. In general it was a tyranny of the most purblind and intolerant kind, founded on the right of employers to make large profits by exacting the greatest service for the least possible pay. There were many sane and considerate employers in that inhuman period, and any just account of it should record that the better elements were ever increasing in numbers, and many were constant in condemning and countering the bad elements, both on industrial councils and in public, and it should further be added that the secret of the British industrial movement was that it released the energies of enterprising men. True, a society actuated more by Christian principles would have advanced more slowly and more equitably. But it would surely have retained the essential principle of leaving men as freely as possible to make their own projects and to follow them through, accepting the right of men to own and develop productive property, and to engage other men to work for them. If this principle had not ruled throughout the last 150 years Britain would be a very different land today. But, notwithstanding the accumulating evidence of the better elements among the early industrialists, in the main the industrial revolution was a regime that gave admirable service to its customers at the price of denying elementary rights to employees in the business.

Against all this the succeeding generations have violently reacted. The history of those increasing reactions would themselves occupy a paper. If left a great legacy of resentment and bitterness. May it be possible that it left also a more valuable legacy, and that the challenge that is the subject of this review is born of an urge to give expression to it? May it be that it is partly an attempt to meet the age-old need for man to seem significant to himself—to have his human rights recognised and his opinion count, and his voice heard in the conduct of the world he works in instead of being a mere cog, an order-taker; and partly an urge thus to solve the problem of incentive that makes work worth doing and life at work worth living?

Two Methods of Approach

It may be that it is against the practical realisation of these ideals that the concept of any share in management should be judged. Will it solve the social problem

of making every man's and woman's working life worth living in a manner suited to our time? The right answer here is critical for the future of British business. Indeed, it raises an issue on which our national survival may depend. In arriving at it we have to distinguish sharply between two separate methods of approach and two separate sets of benefits:

(1) Those that can only be conferred by partnership (commonly termed co-partnership), and understood to imply a legal proprietary right, either by ownership of company shares, or by a contractual share of profit.

(2) Those that are the product of good management, including the modern conception of personnel management, joint consultation, and the creation of good labour relations with the management. These are independent of the partnership concept and can be, and are, supplied without it.

Let us examine the main elements in both these methods of approach. One is the use of committees in executive management. Committees can be useful or a danger to good management; they can be used to evade the need to make decisions and to evade the responsibility for making them, which should be clear and personal. There is a lot to be said for committees wisely and profitably used; and a lot to be said for the cynic's jest that the ideal committee consists of three people, of which one knows his own mind and the other two are at home with a cold in the head.

Co-partnership

And there is effective joint works consultation. Co-partnerships may have it, but so may other businesses that are not partnerships, and the current examples of good joint consultation are not co-partnerships, but ordinary private enterprises—though it is fair to say that they are not run by ordinary men. To those of us who are familiar with the system freely used by many non-partnership businesses, in which any employee can raise any question and get it discussed freely, either face to face with management or by the Works Council, with a straight answer and perhaps action to follow, discussion on the rigid co-partnership lines suggests more froth than beer, and more likely to lead to friction than satisfaction. Moreover, security of tenure is of obvious importance, and partners who may depart on one month's notice or resignation are only partners in name.

The conclusive test, I suggest, is whether the co-partnership idea in practice results in much more effective management, better morale, better time-keeping, larger and better output per worker, per hour and per week, less labour turnover and more willing team-work all round—whether, in fact, the business that has it, does much better as regards long-term security and with more goodwill and absence of friction, than a similar business could hope to do if not run on partnership lines.

I myself have not seen or heard example or evidence that "co-partnership" has put a firm's structure or its worker-partners into any better position than its many successful business rivals have done.

But when all that is said—and about an experiment so important it is necessary to ask a series of searching questions—there can be no doubt about the sincerity of those who have advocated the system, devoting to it so much of their time and probably their money.

Origin of Suggestion

The core of our problem seems to me, therefore, to lie in the question, "where does the suggestion of joint industrial management come from?" Is it a suggestion made by industrial workers, or a demand made by certain union leaders? It finds no place in the official doctrine of Socialism, it was unanimously described as both "undesirable and unworkable" by the Committee appointed to examine it at the International Labour Conference held at Brussels last autumn and it is not supported by many union leaders. And, speaking as an industrialist, I have yet to hear any reference to it by factory workers. One is disposed, consequently, to enquire whether the demand comes from those actuated by political motives plus a desire for personal position and power? In that case, if put into operation, it would rapidly run into conflict and head-on collision with management, and simultaneous hells would quickly gape for Britain, trade unions, and all true trade unionists. Or is it a suggestion—a challenge—from workers and patriots who recognise that it is the plain duty of this country to save itself, that we must set about the task of working out our salvation with diligence, and that it will require a new industrial approach to put our house in order and free ourselves from the risk of national bankruptcy when Marshall Aid comes to an end?

The issue is so plain that the criteria by which safety is achieved can be measured; and similarly there are the criteria of national decay and mortal weakness. The criterion for disintegration and national suicide is found in the spectacle of division and discord. The criteria of safety are found in the development of a national unity of purpose and in the spectacle of industrial co-operation.

It is here that three further inches of industrial background should be added if this necessarily brief review is to be in proportion.

The first is that trade unions came into being to correct by combined action the injustices and labour exploitation which marked much of the early industrial development throughout the world. The growth of trade unions and their achievements was one of the greatest British developments of the last century. The story of their upward struggle is rich in courage, loyalty and common sense responsibility. Trade unions won power because they proved to be a sound and stabilising influence. That is the crux of the matter—*they gained power for the very reason that they promised stability*. The stability they promised came from the fact that the union leaders could go into a conference room and negotiate terms with the confidence that those terms would be regarded by both sides as a contract to be honoured and observed. Thus the machinery for settling all grievances and disputes was built, and collective bargaining became the foundation of industrial peace in this country.

Today those achievements and benefits are being placed in danger by the modern weapon of the illegal strike.

The second is that the economic security of this old country stands or falls on a number of assumptions that were generally accepted in the last century, and have been increasingly challenged in this; that industry must be flexible and in process of constant and rapid change, with the elimination of the costly way in favour of the least costly way of doing things going on all the time. Our national recovery will not be strong and enduring unless industry is free to develop a keen and adventurous spirit in management, and there is a readiness to welcome new and improved methods of labour. I well understand that it is natural for men and women to strike roots, and to desire to do the same work in the same place and way. But let it always be remembered that industry is Britain's last treasure, and that unless British industry is competitive in cost of production in the markets of the world, poverty and want will soon be nation wide.

American Practice

The third inch of industrial background is a reference to the difference between the American Labour Movement and the British, for it is a profound one. It boils down to this: In America the Labour Movement was dedicated to work within the framework of co-operation with with industrial enterprise. The British Labour Movement is a political one, intent to obtain all industrial reform by legislation. The labour unionists in America disagree with a political labour movement, believing that the best gains can be obtained for the workers at the bargaining table with the employers. Both sides work together to make industry as productive and profitable as possible so that investors can obtain assurance of a fair return, management, payment for initiative and direction, and labour can be assured of a fair day's pay for a fair day's work, with the accompanying greater job security—in other words the production of a large industrial cake from which all can have the assurance of the large slice which only prosperous industry can guarantee. In this country industrial profits are regarded not as a sign of efficiency but as evidence of the sin of exploitation. In America this judgment is reversed. That nation regards industrial development and profit as a source of new opportunity, and will readily accommodate itself to the opportunities and the dangers of a constantly changing situation. Small wonder that American productivity has attained levels that have brought national and individual prosperity to that country which far surpass those won in any other country.

These are reflections that are known to all thinking men. They present a problem which demands a solution. They also present the main purpose of this paper; to meet the challenge by issuing the essential counter challenge. Is this challenge to share industrial management a desire to share difficulties, to promote industrial justice and peace, to reduce production costs by increased productivity and so increase the stability of British industries? Is it, in fact, a desire to raise new layers of unity and co-operation to the surface of factory life?

It was my original intention that this paper should end with this vital query. But I have been counselled to make my own opinion and judgment clear. I will endeavour to do so without reservation or ambiguity.

Vague Idealism

I am in agreement with Sir Stafford Cripps that the project of joint industrial management is "little short of vague idealism," and that the proposal, even if born of worthy aspirations, does not come within the category of practical things. I am in entire sympathy and agreement with those who contend that only the super-prejudiced will deny that the time is ripe for the balanced consideration of our future pattern of living, and that only the ignorant and the blind will assert that there is not a great and growing public desire for radical social change. And if the majority of the nation is in the right mood for beneficent reform, God forbid that there should be any dearth of goodwill.

But before industry—which I again repeat is now the whole treasure of the people of this island—is committed to any radical change, the change requires clear

definition. For there are many varieties of so-called reformers, and only the normal percentage are found to be men of goodwill. I believe that it is far better to let co-operation grow through mutual good faith and goodwill than prematurely forge links that may too easily chafe and irk. If the change is rushed, then however sincere the advocates, it will hardly result in the society or the industrial organisation they seek to bring about. For there is no older lesson in history than that which teaches that what hasty reformers actually achieve is but a caricature of what they intended and hoped for. Once take the wrong road, and it may be a long time before our successors find the right one. It is hardly possible for hasty action, with its inevitable makeshifts, to take the place of balanced and long-term planning. No new Britain would be built, no industrial peace and security would result, if the fundamental factors I have enumerated are ignored. It is because such factors have been so frequently ignored, or skated over, in the past that the history of man's effort to better himself make such poor reading. It is better to be frank—as Sir Stafford Cripps and many union leaders have been—than to start with wishful thinking on courses which lead sooner or later to frustration and dead-ends.

There is no doubt about the rickety and precarious foundation upon which our country's future now rests. And it is for this reason that, although I am in deep sympathy with labour's long and hard struggle with the selfish element in industrial life, I venture to say that when class prejudices, and a misunderstanding of the essential nature of the profit motive, are preached with effect, it is difficult to avoid the paralyzation of industrial initiative and enterprise. The essence of this false doctrine is its succeeding sterility. Thus it is that a chronic anxiety and a deep sense of insecurity are enfeebling influences on industrial initiative in any country. And it is with both this sympathy and this misunderstanding in mind that I venture to say, with great respect, that it is now essential for the trade union leaders to decide how far they have to be the guardians of the public interests and how far they are the workers' pressure-group.

Tolerance first came from equality of struggle.

Community of interests is the root of justice; community of suffering the root of pity; and community of joy in worthy and desirable performance the root of love. One can hardly insist too much, in the present state of things, when joint industrial initiative is the last shot in our national locker, on the efficacy of mutual understanding, mutual goodwill, and mutual trust and confidence in stimulating to ardent co-operation for the achievement of the end in view. We will fall completely as a nation if any large section of employers remain swayed, or any large section of workers continue to believe that industrial leaders remain swayed, only by the mastery of material calculation. For this, as we see today, ends for want of the energy obtained from co-operative ardour. We have need to keep the sluices open for influence of the better sort.

Let, then, all men of goodwill stand united. Let them seek, not themselves and the things that are theirs, but the security and safety of their country in its urgent need. Let them not urge their own ideas with selfishness or with undue persistence, but be ready to abandon them, however admirable, should the greater common good clearly require it. For this nation and civilised society will be saved by men whose aspiration is Christian, who pay daily regard to the dignity of the individual and the duty of man in all his dealings with men, and whose aims are "industrial unity and co-operation to the surface of factory life."

(Our report on the Discussion appears on pages 54 and 55 of this issue.)

A very successful two-day exhibition of Arts and Crafts was staged in the Old Horticultural Hall, Westminster, by the Central and Northern Divisions of the North Thames Gas Board. Well over a thousand exhibits were on show and they ranged from cabinet and carpet making to a miniature gasworks; in addition, there were demonstrations of pottery making, glass blowing and modelling

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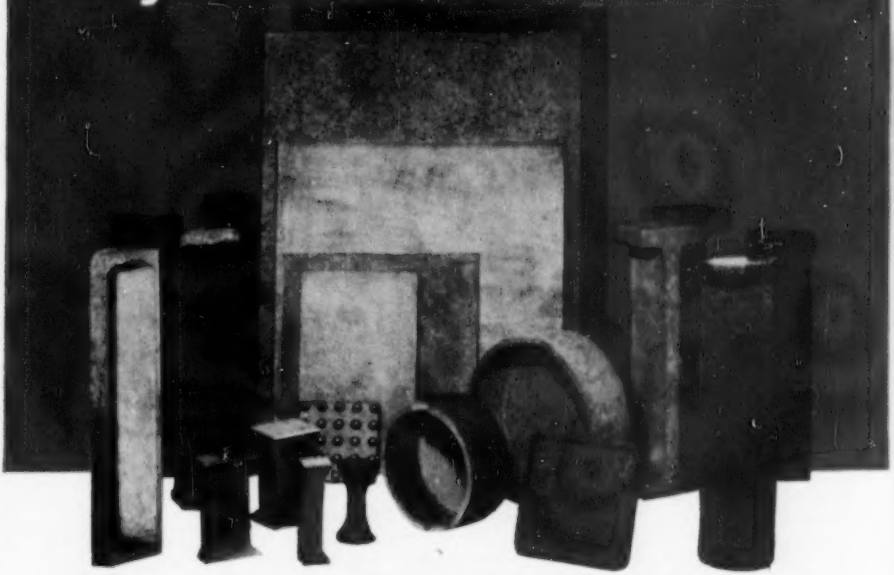

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The Metallising of Non-Metallic Materials

By
G. T. COLEGATE
B.Sc., A.I.M.

IT is proposed in this article to discuss some of the methods available for the metallising of non-metallic objects, with particular reference to the metallising of ceramics and similar materials. The discussion will not be extended to such processes as cathode sputtering, high vacuum evaporation or metal spraying, but will be confined to the less specialised methods, such as the use of metallic paints and the chemical and electro-chemical deposition of metals.

The coating of non-metallic articles with metals is by no means a new process. It was used by the ancient Egyptians, and there are still in existence vases and wooden objects which they coated with metals. However, since that time the art of metallising seems to have been very little practised, if indeed it was practised at all. The work of Jacobi in 1837 is the first recorded instance of the metallising of non-metals in comparatively modern times. Jacobi succeeded in depositing metals on wax, stripping the coating and using it as a negative mould. In the next few years, several people in this country became interested in the process, and in 1840 Murray applied graphite to non-metallic surfaces to make them electrically conductive and therefore capable of taking an electrodeposited coating. In the following year, Jones was granted a patent covering the use of copper powder for the same purpose and Parks discovered how to metallise a wide variety of surfaces by using silver nitrate and reducing it in contact with the surface in order to produce a coating of metallic silver. The silver nitrate technique was elaborated by several other workers, among them Noualheir and Provost who, in 1857, described how a corpse could be metallised by using silver nitrate. With the increasing interest that was beginning to be taken in electrodeposition, several methods using this technique were evolved in subsequent years.

Applications of Metallising

Many of the original applications of the metallising of non-metallic materials were purely decorative, and were used on leather, fabrics, etc., and for coating such objects as butterflies, moths, leaves, etc. However, while the technique is still widely used for decorative purposes, very many industrial applications have been found for it, such as the metallising of ceramics for electrical contact purposes, the metallising of glass, etc., in order to enable wire to be soldered to it, and the metallising of non-metallic machine parts in order to improve wear, etc., etc.

As might be expected, many of the industrial applications of metallising are to be found in the electrical industries, but metal films on non-metals have other valuable uses besides that of providing an electrically conducting coating. They have been used for the plating of dental plates, for the waterproofing of a variety of porous materials such as cork, and for the coating of a wide variety of plastic articles to confer wearing properties on the surface and also to protect these materials from atmospheric and other influences. In the decoration of glass and china, metallising is extensively used, and it has also found application in the decoration of tiles and terra cotta, though not extensively. One of the most important industrial applications, and one of the oldest, is in electroforming and electrotyping. However, while the general principles discussed here apply to the latter techniques, it is not intended to describe them in detail.

The Process of Metallising

There are several stages in the process of metallising, which may be summarised as follows:

1. *The Waterproofing of Porous Materials.*—It is essential before starting to metallise any object to have it thoroughly dry and then to waterproof it in order that it will not absorb liquid from any of the baths into which it is subsequently placed.

2. *Roughening of the Surface.*—The adhesion of a metal deposit to a non-metallic surface is often greatly improved if the surface is first of all roughened, either chemically or mechanically. Whether or not roughening of the surface needs to be carried out in a particular case will depend very much on the method of metallising that is to be adopted, and also of course on the nature of the surface. Thus, glass and glazed porcelain often need roughening, and so do many plastic materials.

3. *Cleaning.*—It is necessary to remove all traces of dirt, and especially oil or grease.

4. *Application of the Bonding Coat.*—In cases where a metallic powder is to be used, a bonding coat must first be applied to the article. No such coating is needed in those cases where the preliminary coating with metal is to be carried out by chemical deposition.

5. *Application of the Conducting Coat.*—This is the most important stage of the process. As described in detail below, the conducting coat may be either in the form of a conducting powder or else a chemically deposited film of metal.

6. *Application of a Flash Coating.*—In those cases where a metallic powder has been used as the conducting coat, it is frequently desirable to apply a flash coating of silver over it in order to increase its electrical conductivity and thus ensure more even deposition of the metal in the electrodepositing process proper which follows.

7. *Plating.*—Any desired thickness of metal can be built up on the conducting coat by electrodeposition. Copper is the metal usually used, but others may also be employed.

8. *Finishing.*—Very little finishing is normally required, apart from a little light buffing, though in some cases a metal colouring process may be used.

These various stages in the production of metal coatings on non-metals will now be discussed in greater detail.

Waterproofing

Waterproofing must be used on all materials that are likely to absorb water from the solutions used in the metallising process. Such materials include terra cotta, plaster of paris, unglazed porcelain, etc. A suitable formula for a waterproofing medium is as follows:

Rosin	... ...	1 lb.
Beeswax	... ...	2 lb.
Paraffin Wax	...	7 lb.

This mixture requires to be heated until thoroughly fluid, i.e. to about 130° C. Care should be taken not to overheat the wax. The article to be coated is immersed in this molten wax for a period up to about half an hour and is then removed, the wax on its surface allowed to solidify and the excess removed.

A coating of shellac may be used as a waterproofing medium, or alternatively it may be applied over the wax. Metal powder should never be applied direct to the wax unless it is intended to strip the coating after it has been formed.

Roughening of the Surface

For ceramics and glass either sand-blasting or etching in hydrofluoric acid may be used. There are many special methods for application to the various plastic materials, rubber, etc., but there is insufficient room to discuss them here.

Cleaning

As in all forms of finishing, cleaning is important. This is particularly the case when conducting films are to be formed by chemical methods. Unless the surface is entirely free from all trace of grease, etc., uneven deposition will take place and an unsatisfactory finish will be obtained. The method of cleaning used will depend on the nature of the article. Plastics may be cleaned by immersion in a warm dilute solution of a mild alkali. For glass and similar materials a hot solution of chromic acid is effective, though this cannot be used on articles that have been waterproofed with an organic coating.

Bonding Coat

A bonding coat may be put on an article to be metallised and the conducting powder applied to it or, alternatively, the conducting medium may be incorporated in the bonding coat itself and the mixture applied to the work. If the work has had a waterproofing coat applied to it, it is usual to follow this with one or more coats of shellac varnish. A suitable varnish for use in this application is as follows:

Denatured Alcohol	3 parts (by weight)
Orange Shellac ...	1 part (by weight)

The same solution may be used as a pore filler in place of wax, but in this case several coats will normally be found to be necessary. Other resins besides shellac may be used for making a varnish for this purpose. For example, a copal varnish may be satisfactorily employed. The application of the bonding coat to the work may be done by brush or spray, the latter being generally the more satisfactory, especially when properly done, since by the spray method it is much easier to obtain an even coating than by the use of a brush.

Conducting Coat

The work is now ready for the application of a conducting coat, which may be done in three ways as mentioned above.

(*a*) *The Use of Metal Powders.*—If the conducting coat is to be formed by the use of metal powder, it is necessary to apply another coat of shellac or copal varnish to the work, wait until it is tacky, and then apply the powder. Alternatively, the powder may be incorporated in a cellulose lacquer. In the latter case, it is the general practice to give the work a coat of boiled linseed oil on top of the varnish in order to ensure good adhesion of the lacquer. Some go further than this and apply, in addition to the linseed oil coat, a coat of clear cellulose lacquer before applying the lacquer containing the powder. It is doubtful whether such an elaborate procedure is justified in most cases, though the single coat of boiled linseed oil is undoubtedly very desirable. If the powder is applied to the work direct, i.e. without being incorporated in a lacquer, it may be

put on either by spray or by brush, the former method giving more even results. If hand application is used, a fine camel hair brush is the most satisfactory method of spreading the powder over the surface, an operation that requires considerable skill.

Several different metal powders have been used for the conducting coat, the most common being copper. Tin powder has also been used in certain applications, but for most purposes copper is entirely satisfactory. If the powder is to be incorporated in a lacquer, the following is a suitable formula:

Cellulose lacquer	...	1 pint
Lacquer thinner	...	4 pints
Copper powder	...	2 lb.

The composition is not critical and will be influenced to some extent by the nature of the work.

A lacquer containing tin powder has been recommended for use on some types of work. The following is a suitable formula for such a lacquer:

Cellulose lacquer	...	1 pint
Lacquer thinner	...	1 pint
Tin powder ...	...	3 ozs.

Such a coating is usually followed by a coating of copper-containing lacquer similar to the above, but containing less powder.

(*b*) *Chemical Methods.* — Chemical methods of forming the conducting coat are widely used. The commonest metal to be deposited for this purpose is silver, though copper, gold and antimony have been used in certain applications. Chemically formed metal coatings are particularly suitable in those cases where fine detail has to be followed, since with the powder method it is often impossible to avoid obliterating fine lines, etc. In similar applications are used chemically formed films of metallic sulphides which have sufficiently good electrical conductivity to allow them to be sucessfully employed in such an application. Silver and lead sulphides are the ones usually used.

On the whole, it may be said that the use of chemically deposited silver films is the most satisfactory way of forming a conducting coat for metallising non-metals. There are a very large number of patents covering various modifications of the silvering process, but all methods are very similar in the essential details, the solutions used being one containing the silver salt and one containing a reducer.

The preparation of the work for all chemical processes must be very thorough and no trace of dirt or grease must be on the surface when it goes into the solution. The work must not be touched with the fingers between cleaning and silvering. There is one other stage in the preparation of work for silvering that is nearly always used, namely, the work is dipped in a solution of stannous chloride and then rinsed. This step is not always employed, but it is widely claimed that it gives a much more satisfactory job. The concentration of stannous chloride is not critical, 5 or 6 per cent. being an average value.

A suitable silver solution for use in silvering a wide range of materials is made as follows:

Silvering Solution

A solution of ammonia is added gradually to a 10 per cent. solution of silver nitrate in distilled water. The first addition of ammonia causes a precipitate to form in the silver nitrate solution, and as further ammonia is added the amount of precipitate gradually increases until a certain stage is reached when further additions of ammonia gradually begin to dissolve it. When the precipitate has almost disappeared, additions of ammonia should be made very carefully, and with thorough stirring between them, otherwise there is a risk of adding a considerable excess of ammonia. The addition is continued until the precipitate is just dissolved, and then a very slight excess of ammonia is finally added.

Another suitable silver solution may be prepared in the following way. Equal volumes of a 5 per cent. caustic potash solution and a 10 per cent. silver nitrate solution are mixed together. A precipitate is formed immediately and this is dissolved by the gradual addition of ammonia, solu-chemicals should be used, and they should always be dissolved in distilled water. Silvering solutions are sensitive to the presence of traces of impurities, and every effort must be taken to avoid contamination. The same applies to the reducing solutions used with the silvering solutions.

There are a very large number of reducing solutions that may be used in conjunction with the silvering solutions mentioned. One formula is as follows:

Sugar	...	1 oz.
Nitric Acid	...	0 1 oz.
Water ...	...	10 ozs.

This solution should be boiled for a quarter of an hour before use, but must be allowed to cool before adding to the silver solution. Unfortunately, the reducer will not store well, but can be made to do so by the addition of half an ounce of alcohol.

The actual silvering operation is carried out by mixing equal volumes of the silvering solution and the reducer and immersing the article to be silvered in the mixture for a few minutes. The temperature of operation of the silvering process is room temperature.

Gold films may be deposited on non-metals by chemical precipitation in much

the same way as silver films, though they have not nearly such a wide application. In depositing gold films a treatment in stannous chloride is invariably given, the concentration of the solution being about 10 per cent. The articles are removed from the tinning solution, swilled, and immediately treated in the gold solution. It goes without saying that cleaning of the object prior to treatment must be very thorough, as in the case of the silvering process.

Gold Deposition

For gold deposition three stock solutions are normally used, as against two in the silvering process, but the principle is essentially the same, namely, the reduction of the metallic salt to the metal in an alkaline solution. The following are typical solutions suitable for the chemical deposition of gold:

(a) Gold chloride
3 per cent. in distilled water.
(b) Sodium carbonate
10 per cent. in distilled water.
(c) Formaldehyde (40 per cent.)
5 c.c. in 100 c.c. distilled water.

The three solutions are mixed together in equal parts immediately before use and the article to be gilded is placed in the mixture, which is gently agitated while the gold is being deposited. The temperature of operation is about room temperature or a little above. There is a fair amount of latitude allowable in the concentration of the various solutions.

Methods are available for the chemical deposition of other metallic films besides gold and silver, among them nickel and antimony, but these are not of much practical importance.

Another class of film which is used in the metallising of non-metals is one of silver sulphide. There are two main methods of forming silver sulphide films, one being a process in which the silver salt is incorporated in a lacquer or varnish film and then exposed to the action of hydrogen sulphide, which converts the surface layers into silver sulphide which is a conductor of electricity. The other process is one in which the silver nitrate is absorbed into an existing varnish film from a solution.

In the first method, the most usual type of film is one of shellac varnish. A suitable formula is as follows:

Shellac	... ...	5 ozs.
Alcohol	... ...	1 pint
Silver nitrate	...	1 oz.

This solution is applied either by brush or spray, and when dry the article is exposed to hydrogen sulphide generated by treating ferrous sulphide with dilute acid. No further treatment being necessary, apart from a rinse in water, the work can be transferred direct to the acid copper bath.

If an article has already been coated with a shellac varnish as a pore-filling coat, the silver nitrate can be absorbed into the surface of such a coating by immersing the article in a solution of silver nitrate in alcohol and then, after drying, it is exposed in the same way as above to hydrogen sulphide. A satisfactory solution of silver nitrate for the purpose is:

Alcohol	...	1 pint
Water	... ...	2 pints
Silver nitrate	...	2 ozs.

Lead sulphide films may be deposited on non-metallic articles in much the same way as described to silver and gold films. The following formulae give a series of three solutions suitable for the deposition of lead sulphide films. In this case no pre-treatment with stannous chloride is necessary.

(a) Lead nitrate	...	5 per cent. in water
(b) Caustic soda	...	10 per cent. in water
(c) Thiourea	...	4 per cent. in water

The solutions are mixed together in equal parts and used at room temperature.

(c) *Metallic Paints.*—Metallic powders incorporated in a suitable binding medium which may be either an oil or a lacquer, may be applied to the surface of porcelain or similar material and then fired to fuse them to the article. Silver and gold are often used in this way, but platinum and other precious metals are also used occasionally.

There are a large number of formulae for the deposition of silver on porcelain and glass by this method. One that gives satisfactory results is as follows:

Lead oxide	... ...	10 grammes
Borax	... ...	8 „
Boric acid	... ...	20 „
Powdered glass	...	10 „
Potassium nitrate	...	30 „
Silver chloride	...	30 „

These materials are mixed intimately together and then incorporated in oil to make a paint-like material which is applied to the article and then fired. The temperature of firing depends on the type of base to which the paint is applied and ranges from about 500° C. to 900° C.

Application of a Flash Coating

In those cases in which metallic powders have been used as a conducting coat, the work may go straight to the plating bath, but it is more usual to first of all treat it in a silver flash bath, in which an immersion deposit of silver is formed on the copper. The purpose of this is to improve the conductivity of the copper film, since it is found in practice that if the coppered article goes straight into the copper plating bath it takes some time before the plate begins to form evenly all over. By using the silver dip, more or less even deposition

takes place all over the article as soon as it is immersed in the copper bath and the current applied.

A suitable silver dip for this purpose is as follows:

Silver cyanide ...	6 ozs. per gallon
Sodium cyanide	7 „ „ „

The solution is used cold. An immersion time of 10-20 seconds is sufficient to give a good coating of silver.

Plating

For plating, an acid copper solution is almost always used. This type of solution is easy to operate and thick coatings can be built up without difficulty. The following is a suitable formula:

Copper sulphate	20 ozs. per gallon
Sulphuric acid	5 „ „ „

A wide range of concentration for both the copper sulphate and the sulphuric acid is permissible. The current density used with a solution such as the above is 60-100 amps. per sq. ft. Addition agents are often added to the acid copper bath in order to obtain smoother deposits and also brighter ones. Gelatin and glue are used for this purpose and give good results. The important thing to remember in this connection is that these addition agents, if present in excess, will give rise to a poor plate. The usual concentration for either gelatin or glue is about 0·02 ounce per gallon of solution. Additions are needed from time to time, and with a little experience no difficulty will be found in deciding when such additions are required.

Agitation of the solution by blowing air through it gives improved results, but this is not an essential part of the process.

Occasional analyses of the bath should be made for copper and sulphuric acid content to ensure that neither is varying seriously.

Finishing

Very little finishing is normally required on the copper deposit. Buffing is all that is usually done, though occasionally a little grinding may be necessary. The rate of deposition of the copper influences to a considerable extent the amount of finishing needed. For example, if deposition is carried out rapidly in a bath deficient in addition agents the surface will, in general, be rougher than if deposition had taken place steadily in a well balanced solution.

AIR CONDITIONING BOOKLETS

WE have just received two interesting publications from the Sturtevant Engineering Co. Ltd., Southern House, Cannon Street, E.C.4.

The first, No. 4001, deals with Sturtevant Air Washers, which are made in two standard types. The short type, or humidifier used in plenum ventilation plants, produces a moderate cooling effect in summer and humidity suitable for human comfort in winter. The longer type provides suitable conditions for a number of air-conditioning applications.

Both types of equipment are fully illustrated by diagrammatic sketches and photographs, whilst specifications are given for the various sizes in terms of air volume in cubic feet per minute in relation to overall width and height.

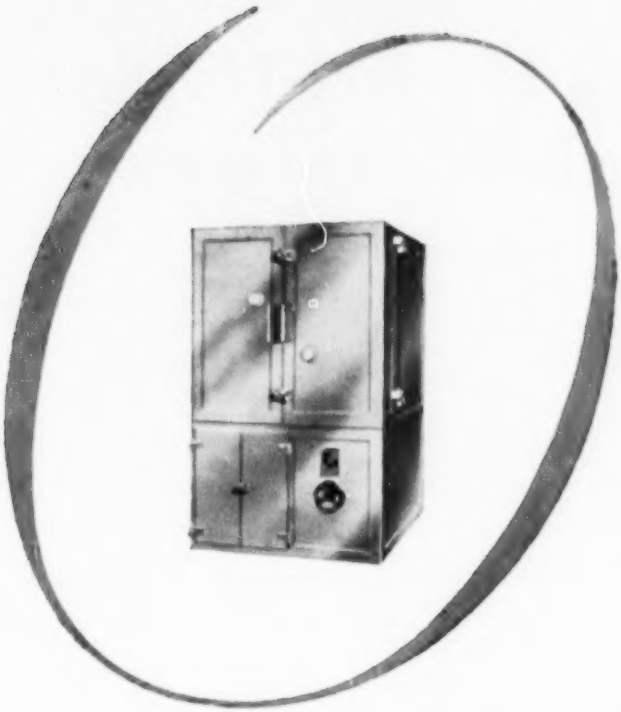
Typical applications are shown by photographs, two of particular interest being one of the plant operating in the premises of Harrods Ltd., Knightsbridge, and the other in the Pontypool factory of British nylon spinners.

In leaflet 4002, there is a technical description of the Sturtevant viscous-type Air Filter, which is used to remove dust which would otherwise be carried into a mechanically-ventilated building, or to prevent damage by dust to delicate apparatus, machinery, stocks and so on. There is a technical description of the method of operation, together with data on dimensions and weights, the capacity, the erection of the Filter and notes on the cleaning procedure.

BRITISH INDUSTRIES FAIR

OVERSEAS buyers from Scandinavia visiting the Fair from 8th May to 19th May will benefit by concessions announced by four shipping services. Reduced fares will be allowed on the Gothenburg/London, Esbgerg/Harwich, Oslo/Gothenburg and Harwich sailings to travellers presenting official B.I.F. invitation cards. The respective companies are: Swedish Lloyd Steamship Co. Ltd., United Shipping Co. Ltd., Ellerman's Wilson Line Ltd. and the United Baltic Corporation expect to announce the same facilities on the Gydnia/London service during the Fair.

Lithopone allocation freed from control.—The Board of Trade announces that with effect from 31st January, 1950, it will cease to control the allocation of lithopone manufactured in the United Kingdom. The distribution of imported lithopone is already free from control. Home production is not yet sufficient to meet all orders received by the makers.



IT'S NOT TEMPERAMENTAL

The ability of the 'Grafton' Kiln to reach the predetermined temperature with a uniformity that removes all need to 'know' it, is only one reason why it has been acclaimed by potters all over the country.

What is more, the kiln atmosphere being essentially clean and free from sulphur assures no risk of contamination from deleterious gases of combustion.

Complete details and specification on request.

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Design of a High-Temperature Resistance Furnace

THE study of high-temperature reactions is limited by the difficulties encountered in obtaining and controlling desired temperatures and purity of atmosphere. The purity of the gas introduced into the heating chamber and on the degree of contamination caused by materials within the furnace. Insulating materials within a furnace are frequently a source of such contamination, either directly or because of materials deposited on the insulation in previous firings. In addition the problem of outgassing the insulation for firings *in vacuo* is considerable. If no insulation is used in the furnace, contamination of the atmosphere is minimised. The absence of insulation also increases the rate at which the equilibrium temperatures are obtained. The furnace described here was designed to meet the need for an easily controlled high-temperature furnace capable of maintaining a pure atmosphere. It has met the required conditions and has given satisfactory service since 1948.

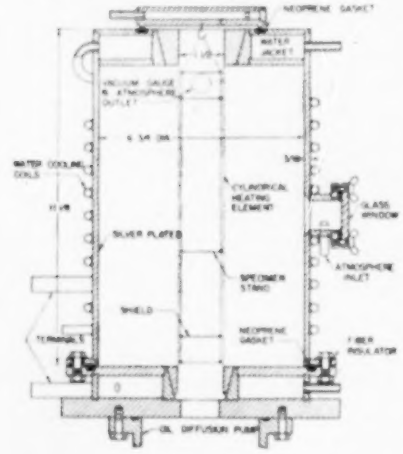


Fig. 1. Cross-section of furnace

The furnace shown in Fig. 1 consists essentially of a molybdenum or tantalum element surrounded by a water-cooled brass case. The inside of the brass case is silverplated to reduce radiation losses and to facilitate cleaning. A molybdenum or tantalum sheet is rolled to form an open-seamed cylindrical element 1½ in. in diameter and 12 in. long. The open seam is approximately ½ in. wide. The ends of the element rest in holes through the upper and lower removable contact cones, permitting movement of the element as it expands and contracts. The lower contact cone is made smaller than the upper cone to permit removal of both cones and element without unbolting the shell from the base plate. A Pyrex-brand glass disc mounted over ¼ by 1 in. vertical slot in the furnace case is used as a window.

Voltage Control

Convenient power-input control is achieved by means of a 12·5 kva. voltage-control transformer. The controlled voltage is applied to a 10 kva. transformer having a maximum output of 1,000 amps. at 10 volts. The transformer in turn is connected to the furnace. The furnace base plate is electrically insulated from the remainder of the shell by a Neoprene gasket and fibre washers under the bolts. The upper end of the element is in contact with the upper part of the shell, which forms one electrode whereas the lower end of the element is connected to the base plate, which forms the other electrode. A zero to 50 ammeter between the two transformers indicates the current being drawn by the low-voltage transformer.

The furnace is designed for vacuum or atmosphere firings. To prevent oxidation of the element, hydrogen or noble-gas atmospheres are used.

The vacuum system consists of a

metal diffusion pump backed by a mechanical pump. The diffusion pump is capable of pumping 275 litres per second at a pressure of 10^{-4}mm. Hg and produces an ultimate vacuum of 5×10^{-6}mm. Hg at 25° C. It is bolted directly to the bottom of the furnace. The mechanical pump has a free-air displacement of 1·7 litres per second and attains an ultimate vacuum of 5μ.

The forepressure is measured by a McLeod gauge which is used for intermittent readings from 0·001 to 1.0 mm. Hg. It is connected to the system between the diffusion pump and the mechanical pump. The vacuum obtained in the furnace is measured by a Philips gauge that gives continuous readings from 2×10^{-5} to $2{\cdot}5 \times 10^{-2}$mm. Hg. Unlike most high-vacuum gauges, this gauge is not harmed when subjected to atmospheric pressure while in operation. The Philips gauge is attached to the system in the atmosphere-outlet pipe (see Figs. 1 and 2).

When an atmosphere is introduced into the furnace, it enters at a point between the window and the cylindrical case. The flow of the atmosphere past the glass tends to prevent clouding of the window by vapours from the furnace. The atmosphere outlet is located near the top of the case. Helium and hydrogen gases are normally used for this furnace because of the ease of purifying them with an activated charcoal trap immersed in liquid air or liquid nitrogen (see Fig. 2). To indicate the flow and to prevent back diffusion of gases, the atmosphere leaving the furnace bubbles through mechanical-pump oil and then enters a flue.

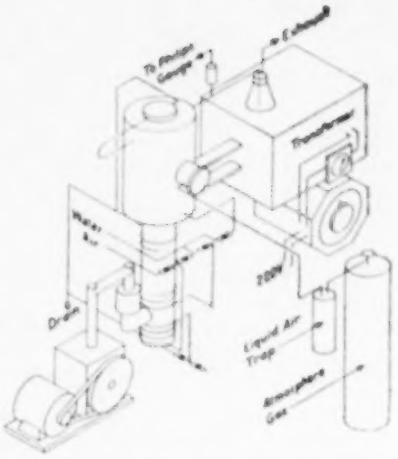


Fig. 2. Schematic diagram of furnace and equipment

Operation

Specimens to be fired are suspended inside the cylindrical element on tungsten wires connected to a hook in the centre of the lid. By using circular radiation shields of molybdenum or tantalum above and below the specimen, it is possible to obtain nearly uniform temperature distribution throughout a specimen length of at least 5 in. In fact, the difference in the temperature between the ends of a 5 in. specimen is of the order of 5° to 10° C. at 1,700° C. The slit in the element permits the operator to view the specimen throughout its entire length.

When the specimen is in place, the furnace is evacuated for either atmosphere or vacuum firings. When the mechanical pump has reduced the pressure to 0·1 mm. Hg, in 2 to 3 minutes, the diffusion pump is started. A vacuum of 0·1μ is obtained in about 10 minutes. Cooling water is turned on. If a vacuum firing is to be made, the power is turned on and the specimen is brought to temperature. For an atmosphere firing, the diffusion pump and Philips gauge are turned off and the atmosphere is introduced into the furnace. The mechanical pump is shut off and the pressure in the furnace is allowed to build up to slightly above atmospheric pressure. At this point, the atmosphere-outlet valve is opened and the firing is started. At any point in the firing cycle a conversion from vacuum to atmosphere or vice versa can be made. The introduction of the atmosphere while the diffusion pump oil is hot causes most oils to deteriorate rapidly. A silicon diffusion-pump oil is sufficiently stable, however, to give satisfactory service under these conditions.

The heating rate is controlled by the variable transformer and can be varied over a considerable range. For example, the surface temperature of a small specimen fired in helium

can be raised above 2,000° C. in 30 seconds. At the other extreme, the specimen can be heated as slowly as desired. Cooling rates can be varied in a similar manner. Temperatures are measured optically through the window and slit. Since near-black-body conditions are obtained within the heating element, the temperature readings are corrected only for the absorption of the Pyrex-brand glass window. The accuracy of the temperature readings has been checked by melting several metals, and the melting points obtained are in good agreement with those given in the literature. In contrast to wire-elements it is found that the temperature of the cylindrical element is only slightly greater than that of the specimen.

In the firing of many materials, volatile products that deposit on the cold walls of the furnace are obtained. The furnace is easily disassembled for cleaning by withdrawing the element and unbolting the case from its base. Cleaning is accomplished with a soft cloth and acetone.

Because there is no insulation in the furnace, it is possible to maintain very pure atmospheres during firing. Easily oxidisable metals, such as chromium and titanium, have been fused in a helium atmosphere without any visual evidence of oxidisation.

The furnace described here was designed for use to 2,000° C. Although a higher temperature than this was obtained (2,075° C.), it is not the limiting temperature for such a furnace. A greater power supply and more efficient water cooling would permit the attainment of higher temperatures. Radiation shields around the element could also be used for this purpose: they were not used for this furnace because of the desire to keep the design as simple as possible.

F. H. McRitchie, N. N. Ault, *J. Amer. Cer. Soc.*, 33, 1, pp. 25/26, January, 1950.

Electrically Heated Clay Screens

A PROBLEM confronting the clay industry has been the blinding of screens during the sizing operation.

All clay, when mined, contains some moisture, varying from 2 or 3 per cent. to 11 or 12 per cent., depending upon the method by which it is mined, its location in the ground, and weather conditions. When clay is ground, the moisture flows along the natural cleavage lines of the clay particles, which become the outside of the individual particles. The surface tension of this moisture yields weight-supporting qualities. Depending upon the moisture content and the size of the particles, the surface tension of the moisture may or may not be sufficient to support the weight of the particles. When it is sufficiently high, the individual grains will adhere to the screen wires or to each other. Although the first layer of such grains may not blind a given screen, as successive layers attach themselves firmly together, the screen openings gradually close and blinding occurs.

This effect is shown in Fig. 1, on a 20-mesh screen with 0·032 in. openings. Only mechanical agitation was provided for 15 minutes prior to making the photograph. Moisture content was estimated as about 5 to 6 per cent.

The surface temperature of water decreases with an increase in temperature, so that by lowering the surface tension of the moisture on a given clay particle, making it possible by application of heat, to such an extent that it will no longer support the weight of the particle.

One of the latest developments is electrically-heated screens which lower the surface tension at the point of contact of the clay with the screen wire. Heat is generated by passing electric current through the screen wires themselves. For efficient operation, the amount of heat must be variable, as moisture content varies over a wide range. Control of the power input to the screen provides for this.

There are several precautions which should be taken before installing electric screen heating:

(1) Excessive screen heating will shorten the life of the screen.

(2) When screens are kept completely clear, grain size which a given screen opening passes will rise. Therefore a finer mesh screen must be utilised to keep a constant size between that obtained before and after the screens are electrified.

(3) The proper wire size in the screen which will lend itself to economical heating and allow maximum production must be obtained.

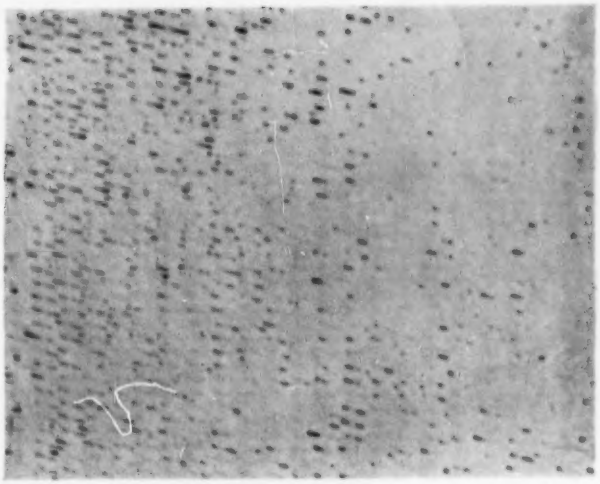


Fig. 1. A 20-mesh screen with 0·032 in. openings, blinded by clay with 5 to 6 per cent. moisture

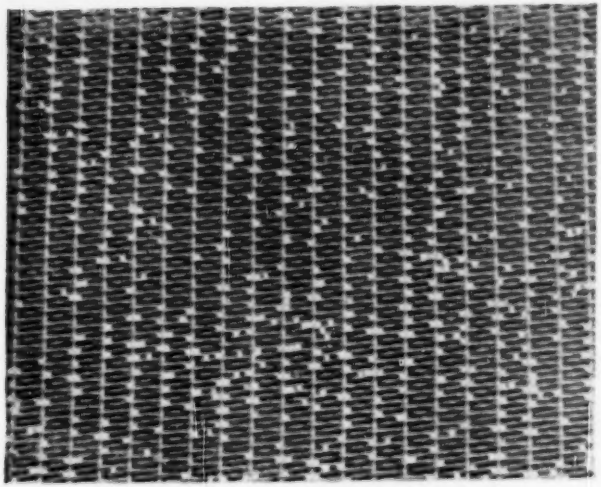


Fig. 2. The same screen shown in Fig. 1, with electrical heating

(4) If barium salts are used in the dry state, careful consideration must be given to the proper point of application to the clay.

(5) Proper design of electrical facilities must be carefully planned, so that no danger to life or property exists.

(6) The economics of such an installation must be carefully studied to determine if such an investment is warranted.

Amer. Cer. Soc. Bul., January, 1950.

BRITISH CERAMIC SOCIETY

A Correction

IN the February issue of CERAMICS we stated—"Moves are afoot to see how the relationship between the Stoke-on-Trent branch (incorporating Leicester-Stafford District) of the Institute of Clay Technology and the British Ceramic Research Association can be extended and made stronger."

Although the main title stated that it was the British Ceramic Society which was referred to, we would like to stress that reference was being made to this Society and not the British Ceramic Research Association.

Ceramic Technology—A World Survey

PRECIOUS METAL FINISHES ON GLASS AND CERAMICS

THERE are a great variety of precious metal paints in use for application to glass and ceramic surfaces; these finishes are used extensively to obtain purely decorative effects and also, within more recent times, have found very great application in the electrical and electronic fields to confer special properties. Broadly speaking, the majority of the precious metal finishes in use for these purposes consist of solutions of the precious metals, dispersions or suspensoid products of the precious metals, and also they may be mixtures of these two categories which would then classify the product as the dispersion type.

Solution Type Precious Metal Paints

The solution type of precious metal paints may be true solutions of precious metals accomplished by dissolving metallo-organic compounds of these elements, together with other elements outside of this classification and in combinations essential to constituting products which can be classified as: Liquid bright golds; Liquid bright palladiums; and Liquid bright platinums.

All the products of this type must be extremely well balanced from a strictly chemical and a physical chemical standpoint. Those who have a chemical background and are familiar with metallo-organic compounds readily can appreciate the complexity of these products chemically.

Considering these products from a physical chemical angle, the important factors include drying time, applied film flow or secondary flow, setting time, colour of film of applied paint, viscosity, specific gravity, and definition of application. To define these briefly:

Drying time is the period between the moment the film is laid down to the time it takes to dry to a non-tacky state.

Film flow is the degree of evening out, and through this, uniformity of film is accomplished and which incidentally, involves plasticising solvents and mediums.

Setting time is the period between the laying down of the application and the development of tack brought about by the release of solvents through virtue of their evaporation from the film and at this point there is no further cold film flow.

Colour of the Film of the Applied Paint in terms of colour density provides a practical measure of the thickness of the application.

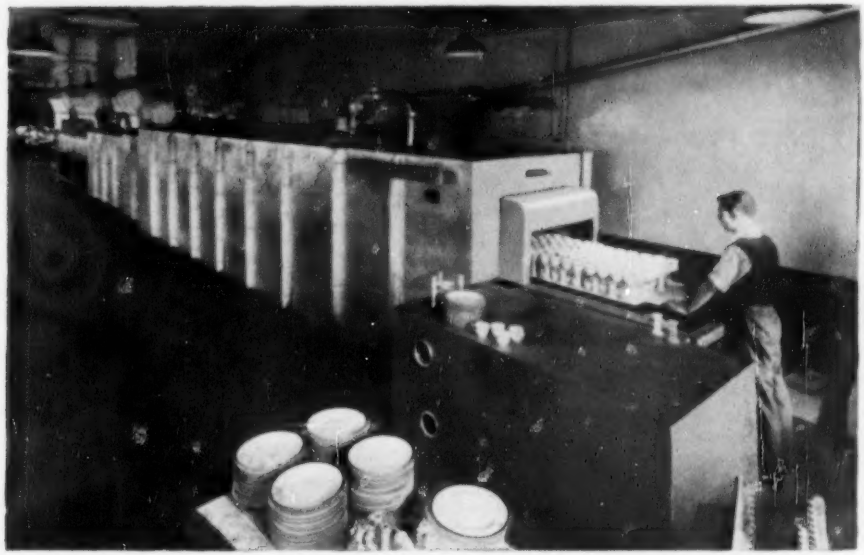
Viscosity measured in poises or centipoises gives standards to be considered in a correlating way to the working properties of the product.

The liquid bright golds, palladiums and platinums, fire out as their names imply, yielding films of metal that are mirrored on glazed surfaces and resemble their respective metals, actually appearing like gold, palladiums, and platinum. These materials can be fired on glass, glazed ceramics as well as dense and polished ceramic surfaces.

Dispersion Type Precious Metal Paints

The dispersion type of precious metal paints are two phase propositions—one, the suspended, finely divided solids, and the other, the dispersing liquid or medium. The solids may consist of gold, silver and some of the platinum elements, either alone or as a mixture. Generally, the thermal binder or flux is interdispersed with the metals mentioned and it too, must be in a very finely divided state. The vehicle, or the

Continuous POTTERY KILNS



Illustrated is an electrically heated kiln—of the continuous mesh belt conveyor type—installed at the Longton works of Messrs. John Tams Ltd., for the enamelling of mixed earthenware. This unit has an output of 4,000 dozen pieces per 168 hour week when operating on a 14/16 hour cycle.

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organic phase or portion of the product, consists usually of one or more body building resins dissolved in organic solvents. The paste products however, have a retarding type resin as a medium, and therefore due to their high viscosity, require thinning before being applied to the surface to be metallised. The nature of the organic ingredients constituting the vehicle must be of such a character as to volatilise completely or break down to non-carbon forming gases. There must not be any carbon in the metallised film after firing. As these products are dispersions they require stirring or shaking intermittently during usage.

Application Methods

The methods generally used for applying these paints are: brushing, dipping, spraying, squeegee printing, and transfer types of printing, such as the roll and steel plate methods.

After the applications are made, irrespective of what method is used the problem of firing follows, involving the firing temperature, firing conditions and the firing cycle. The actual working conditions for the firing stage need to be settled according to the precious metal paint being used and the thermal properties of the ceramic or dielectric material being coated.

Firing conditions are important and influence the adherence of the fired film or metallising very materially. Whenever there are reducing or combustion gases present, adherence suffers, and consequently, the importance of oxidising conditions throughout the firing cycle is emphasised. In other words, there should be a presence of air at all times and circulating away from the painted parts during the smoking off of the organic vehicle, which means that at least up to 450° C., effective ventilation should be provided for. If the firing is in a muffle type kiln or furnace, this is accomplished by leaving the door open a trifle until 450° to 500° C. is reached after which the door may be closed and the firing cycle completed that way. Firing conditions in lehr-type firing frequently requires forced draught to provide adequate firing conditions, but is not always necessary. When the firing equipment is of the latter character, consideration must be given to the amount of work or load that is being fed to the belt and operating conditions adjusted accordingly.

Firing Temperatures

Commercial precious paint formulations are classified for application to glass, glazed ceramics and various types of unglazed ceramic bodies. Mica is in a class of its own and has required the development of many formulations. Firing temperatures recommended for applied silver paints on such material are 600° C. when fast lehr firing is used and 540° to 550° C. where muffle type furnace firing must be employed.

Firing temperatures for glass are dependent on the type of glass to be metallised. Some recommendations for these are: lead glass or soft glass, 480° C.; lime glass, 580° to 600° C.; pyrex glass, 620° to 650° C.; nonex glass, 560° to 600° C.; Vycor glass, 650° to 680° C.; fused quartz, 650° to 700° C.; natural quartz, 540° C.

Firing temperatures for glazed ceramics are dependent on the glaze. Temperatures in current use vary from 600° to 750° C.

Modified ceramic bodies require a variety of firing temperatures, the following will be found to give adherent films.

Aluminium oxide bodies require 850° C. Modified steatite bodies such as zircons and titanates require 800° to 850° C. Porcelain requires 750° C., and steatite the same temperature. Barium strontium and calcium titanates need 750° C. and cordierite 850° C.

The metallising films obtained with the use of the precious metal paints are continuous, and intimately and tenaciously bonded. They are conductive, i.e. permitting current flow and the electrical properties may be adjusted by various means to satisfy a number of electrical requirements. There are films that have been developed for continuous high temperature operation. There are quite a number of films available which permit solder adjoinments to be made between almost any ceramic material and a metal. These paints fire out matt in appearance and may be burnished; this however, is not normally recommended.

DIAMOND CUTTING AND SAWING OF GLASS AND CERAMICS

The cutting and sawing of glass and ceramics for special purpose manufacture is practised to a very considerable extent and for the purpose, the diamond, by virtue of its extreme hardness, has proved itself to be the pre-eminent tool for the purpose. The rapid cutting properties of the diamond are being given more and more recognition, with initial cost considered secondary to the operational speed and economy it can effect in many manufacturing fields.

For the purpose, the diamond may be considered in the form of small cylindrical segments each made up of many minute "chips" and matrix representing the cutting edges of "teeth" ingeniously formed into a high grade flexible steel band. It all adds up to the diamond tooth sawband recently developed commercially —said to be the outcome of five years experimenting.

Ceramics have been cut by the bandsaw method for years, but tool costs have been excessive due to the extreme abrading action encountered. For this reason, low saw velocities have been imperative and feeding pressures held to a minimum so that even the highest quality hardened steel bands could resist a fair, if not economical cutting period. Means of contour cutting such materials as glass, ceramics, marble, granite and tungsten carbides on a production basis was a problem to technicians until the introduction of the diamond bandsaw blade. The contour sawing of steel, aluminium, wood, plastics, etc., has little in common with cutting or shaping of ceramics, glass or marble.

Mechanism of Sawing Action

Under conventional sawing procedure, the teeth penetrate, grip and pull away the material in the form of curled chips, the formation of the latter varying somewhat with the nature of the material and the bandsawing technique employed to remove them.

On the contrary, the diamond sawband actually has no teeth, does not pierce, sheer or scrape like ordinary cutting tools, but rather flakes the material similarly to the sculptor working marble, whose many taps to form and contour are reproduced by the diamond cylindrical segments electronically brazed to each tooth of the flexible band.

A special gullet is provided in the diamond sawband, the purpose of which is to trap and guide the coolant through the work, to keep it cool while flushing the flakes from the diamond segments. Without a coolant, the diamonds would clog and cease cutting; it must be introduced around the entire blade and follow it through the material. Water should be used as the coolant, because conventional forms of lubrication are found undesirable.

Advantages of the diamond bandsawing process are many, among these being: Contours are cut with the same ease as in metals; material is removed intact and further economy results from the $\frac{1}{64}$ in. saw kerf; the diamond band simplifies cutting of many applications formerly restricted to large diamond - impregnated discs; smooth cutting edges offer closer dimensional control and finer finish of cut; the new technique minimises tendencies to vibration or fluttering which are responsible for shattering thinner sections of friable materials; duplicate thin parts may be stacked, properly and carefully clamped and contour sawed simultaneously, a procedure that is of particular value with respect to inlay work.

BERYLLIUM IN CERAMICS

Beryllia Type Porcelain

A new ceramic material with high thermal conductivity and suitable for use as insulation in radar and other electronic installations is reported to have been developed by W. A. Scholes of Rutgers University, N.J. The new material, a beryllia type porcelain, was perfected during a three year research study, in a search for an insulating material to carry off the heat generated in radar and other electronic installations.

A development of ceramic materials had previously been reported from this research centre, with high resistance to extremes in temperature, a factor of great importance in desert or arctic conditions. Earlier

porcelain substances used as insulators had thermal conductivity lower than any of the metals with the result that heat generated by electronic tubes was confined instead of being dispelled. The porcelain developed by Dr. Scholes has a thermal conductivity higher than brass. In addition, the new ceramic has good insulating qualities and is stronger than porcelain insulators now in use.

The material, it is stated, can be prepared for non-military purposes, but the high cost of the principal raw material, beryllium oxide, makes it doubtful if it will be used widely except for military purposes. New and cheaper sources of raw materials would increase the peace time uses.

Industrial Beryllium Poisoning

The extensive use of beryllium compounds in the ceramics industry, particularly in the manufacture of the modern fluorescent tube electric lamps, in which it is used as an internal coating to the glass tube, has focussed attention on the industrial dangers attendant on the use of this material. This matter has recently received prominent notice, arising from the death of a research worker, employed by one of the large electrical companies, after being in contact with beryllium compounds. Following this death from beryllium oxide poisoning, this has now been added to the list of industrial diseases scheduled under the National Insurance (Industrial Injuries) Act.

A large part of the beryllium used in this country is imported, not separately, but already alloyed with copper, the latter forming something like 95 per cent. of the alloy. The poison risk therefore, would appear to be small, except in the chemical works where the beryllium compounds are made and where protective measures are, of course, in force.

In the United States, this risk of beryllium poisoning is rated higher. This is indicated by the fact that, prompted by reports of several cases of beryllium poisoning in connection with the disposal of burnt out fluorescent lamp tubes, eighteen representatives of industry, education, and government groups, have framed a set of precautions to be followed in disposing of such material.

Careless breaking of fluorescent lamp tubes, it was pointed out, might result in skin cuts, giving rise to a condition known as granuloma, a "benign" tumour of the skin. The inside surfaces of many of the fluorescent bulbs made in the United States are coated with a phosphor powder, it was stated, and while its composition may vary, the phosphor usually contains beryllium. There is also the possibility of a health hazard in the inhalation of the dust which is liberated when a tube is broken.

The safeguards proposed are: (1) discarded or worn out tubes should be kept away from children and beyond their reach; (2) tubes should never be broken or placed in incinerators; (3) tubes should be delivered directly to refuse collection wagons or held until such delivery can be made; (4) tubes should never be placed in open containers in the street; (5) if a tube is accidentally broken, the fragments should be swept up and wrapped in heavy paper; (6) broken fragments of fluorescent tubes should never be handled without gloves; (7) if cut by a broken tube, medical advice should be sought at once.

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MR. KENNARD WEDGWOOD

THE death is announced of Mr. Kennard Wedgwood, at Dummerston, Vermont, U.S.A., one of the leading members of the famous pottery firm both in this country and America.

Mr. Wedgwood was 76 and retired only three years ago from the presidency of the New York company—Josiah Wedgwood and Sons Inc.—and from the chairmanship of the British Josiah Wedgwood and Sons Ltd.

Cement Production Record.—It was recently announced that production of cement in 1949 established an all-time record. Deliveries to the home market amounted to 7,429,000 tons, an increase of 536,000 tons, or 7.7 per cent. over 1948. Exports were 1,858,000 tons, an increase of 230,000 tons, or 14.1 per cent. over 1948.

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6. Flax and Linen drying, etc.

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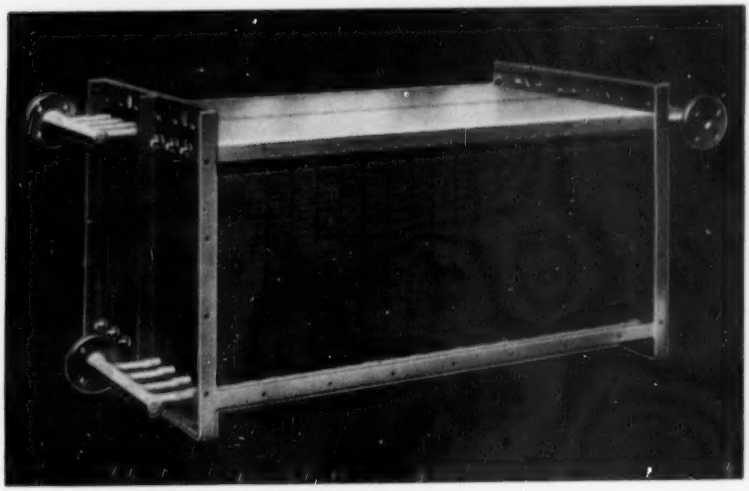
4. Humidity Conditions.
5. Cooling medium and its flow and return temperature.



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The Activities of the

Massachusetts Institute of Technology

CERAMICS DIVISION

This article is compiled from the prospectus of the Ceramics Dept., and we thought readers would be interested in the American approach to Ceramic training.

PALEOLITHIC man's crude vessels marked the first use of materials now in jet engines and gas turbines. Bottles—first made in Egypt from glass strips coiled into a rough flask—are the ancestor of glass brick and spun glass which mark the world's most modern buildings.

Both these represent ceramics, the science of earthy materials processed by heat . . . a science which is nearly as old as mankind itself.

Today, ceramics is one of engineering's highly specialised fields; it holds a position with respect to earthy materials analogous to metallurgy with respect to metals. Among its products are the plates from which 130,000,000 Americans eat and the concrete on which most of them walk. Ceramic products are in every industrial plant and research laboratory across the nation.

Drain tile and china plates have remained fundamentally unaltered for many years, but ceramics is not a field without imagination. Ceramic-enamel coatings are moving inside the 3,000° F. combustion chambers of gas turbine engines. Pottery-type compounds are being combined with organic plastics. Imaginative industrial designers are even talking in terms of hollow glass golf balls which will resist the slices of the non-professional's mashie.

Refractories, cements, drain tile, pottery, glass and porcelain enamel are all ceramics, and though the final products bear little family resemblance their unity in ceramic principles is a fundamental factor in all ceramic research and education. When taken together these specialised ceramic fields add up to an industry which stands well up in the list of American businesses: the 1940 U.S. Census of Manufacturers place ceramics as a $1·4 billion industry, approximately the same size as paper, electrical machinery, leather and tobacco. This 1940 figure represents a gain of £75,000,000 in 10 years.

Research

Research in ceramics is far more than a "build-a-better-mousetrap" operation; it is a fundamental search for materials and methods to meet industrial and human needs. These range from the metal industry's desire for a better grinding wheel to the housewife's dream of a dish cheap enough to be thrown away instead of washed.

The steel industry and many other high-temperature processors have seen recent developments in firebrick and other heat-resistant materials for furnace linings. Aluminium, beryllium and zirconium oxides are now finding their way into industrial uses as a direct result of research into new, very high-temperature applications. High alumina clays can raise the service temperature of firebrick. Silica brick have likewise been improved for high-temperature service by carefully purifying the raw materials. The insulation qualities of furnace linings have been improved to reduce kiln weight and construction costs. In some cases these same improvements have cut kiln fuel bills

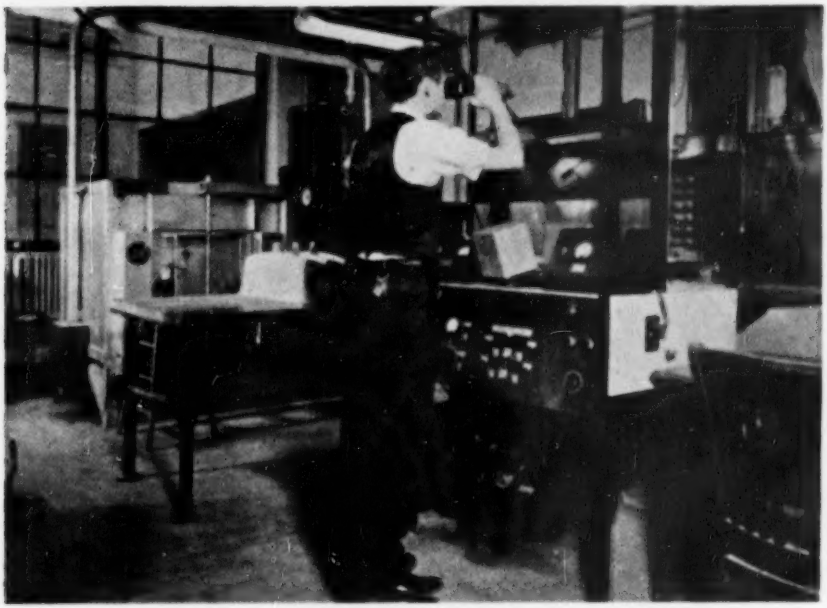
in half. But the demand for better firebrick and refractory material continues, and research is only now beginning to find the answers.

If glass is one of the very oldest of man-made materials, research is also making it one of the newest. "The biggest single factor in the growth of modern architecture has been the superb progress made in glass," is an architect's testimony to the contribution of the glass industry's new methods. Glass brick and glass sheet for exteriors are matched by foam glass, impervious to moisture and chemical attack, for insulating walls.

Glass cloth spun from fibre 0·0002 in. in diameter is flexible, durable, will not shrink, stretch, rot, burn, or fade, and is not harmed by moisture. It enters American homes in the form of draperies, tablecloths and even neckties; in other forms this same fabric makes excellent electrical insulation. A dark-coloured suds-like form of glass can replace balsa wood and cork in life preservers.

The porcelain enamels on sinks and refrigerators are getting better and better — and enamels may soon migrate from the kitchen furniture to the walls themselves. If research can develop methods to reduce setting cost, ceramic tile will move out of the bathroom into other spots where a hard, washable finish in needed. It is already possible to put porcelain enamels on aluminium, and when flexible enamels become a reality this durable finish will find untold new usefulness. Already, porcelain enamel is finding its way into building exteriors, for metal trim and for major areas as well.

Abrasives, too, are part of ceramics —and recent research in these fields has led to less striking but equally important developments. Aluminium oxide grain, long used as a standard abrasive material, has been improved many fold by controlled crystallisation from a melt to produce just the grain size desired. This process leaves each grain with all the facets and sharp cutting edges of a perfect crystal. Diamond grains bonded in a wheel like other abrasives offer new possibilities in production grinding. Porous grinding wheels, where cooling air is forced through pores directly to the grinding surface, have stepped up production.

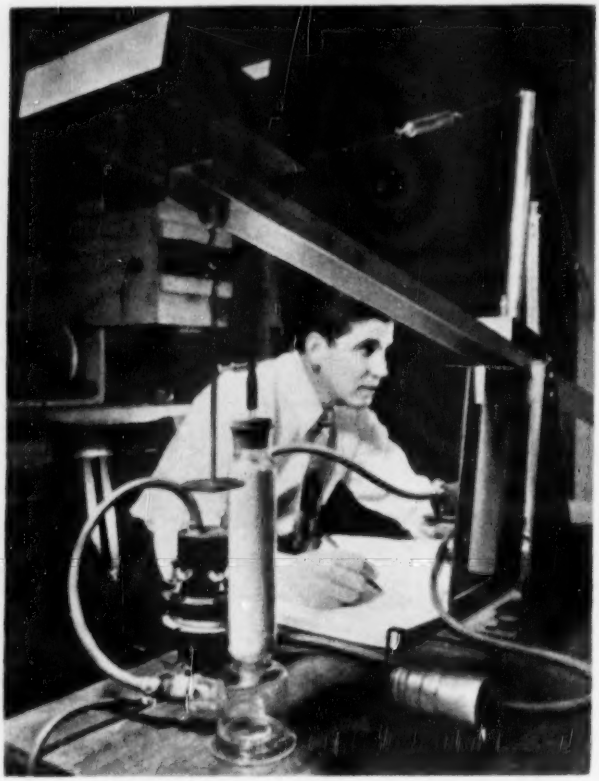


Reading the temperature of a 2,500° C. vacuum furnace, heated inductively at a high frequency

Meanwhile, forming methods for pottery have been advanced to new efficiency by new equipment, including the de-airing extruder. Automatic machines now in operation can carry clay from a de-airing extruder and completely form it into a plate, cup, or other item. Injection moulding and hydrostatic methods for ceramics are emerging from the development stage.

the extreme conditions in guided missiles, jet engines and gas turbines. Atomic energy utilisation will undoubtedly broaden these demands in a way no one can predict. The challenge of new demands for ceramic materials has never been stronger.

The possible meaning of a single new development resulting from research in the ceramic industry is illustrated by this: When steatite was



Another view of the Ceramics Department of the Massachusetts Institute of Technology

Progress in many fields, may depend on methods and products from ceramic engineers. It was from such a demand that steatite electrical porcelains originated; cement which hardens to maximum strength in 24 hours instead of as many days was a ceramic development which turned over a new leaf in construction methods. Research is now in progress to develop ceramic materials for

first proven successful for ultra-high frequency insulation, production jumped 1,350 per cent. inside 24 months. It is events like this which have made ceramics a research-conscious industry.

Scientists prepared for the research opportunities in ceramics need different viewpoints and skills from those trained for plant operation. The research laboratories of industry have

for the most part employed men with degrees in physics, chemistry and chemical engineering to fill technical positions. After coming on the job these men spend months and sometimes years discovering how to apply their previously learned fundamentals to the needs and requirements of the ceramic field.

The recent demands upon the ceramic industry have served to emphasise the need for combining this thorough fundamental training with the imagination and resourcefulness which can be achieved only by the stimulating contacts of graduate work in the field. Indeed, the need for qualified research men in ceramics is such that the combined output of all the graduate ceramics courses in the United States is inadequate to meet the current demand.

Degrees in Ceramics

The most useful tools in ceramic technology are the fundamentals of chemistry and physics; undergraduate majors in these fields, and in chemical and mineral engineering, will find themselves well prepared for graduate work in ceramics. Those with undergraduate degrees in ceramics are of course in an excellent position to continue. In individual cases, previous training in still other fields may be acceptable, with or without intermediate courses.

Work in the Division of Ceramics at the Massachusetts Institute of Technology is given only at the graduate level. Programmes lead to the Degree of Master of Science in Ceramics and of Doctor of Science in Ceramics. These programmes are designed to develop qualities of professional leadership, initiative, resourcefulness, and creative ability; accordingly, emphasis is given to fundamentals underlying ceramic processes, rather than to methods of plant operation and to trade practices.

This work is supplemented by subject material from allied fields necessary to a sound understanding of ceramic principles. For this purpose students in the Division of Ceramics also take work in many other departments throughout the Massachusetts Institute of Technology where they are provided with top-level instruction, in many cases from the country's leaders in their respective fields.

All of this background is applied to ceramics work in the well-equipped laboratories of the Division of Ceramics. Here, students work with equipment designed and built for quantitative research into techniques and properties of ceramic materials. Most of this apparatus is not to be found elsewhere, and much of it has served as models for equipping many of the world's ceramic laboratories.

Further latitude is open to doctorate candidates through the selection of a minor field of specialisation and through provision in their schedules for a limited number of purely elective subjects.

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Research at British Thomson Houston During 1949

WE have recently had an opportunity of reading an article entitled "The Work of the B.T.H. Research Laboratory in 1949" by the Director of Research, Mr. C. J. Davies, M.A., B.Sc.

Among the many investigations in progress is the analysis for carbon.

While the development of orientated sheet requires essential mechanical processes, success in these apparently demands certain chemical requirements. One of the most important of the chemical constituents is carbon and methods for its accurate determination must be set up so that such work can go hand in hand with physical examinations.

A piece of apparatus has been constructed for the determination of very small carbon percentages.

Glass

In the electrical engineering industry, glass is a component which is an essential part of the make up of lamps, valves, cathode ray tubes and miscellaneous vacuum devices, and as such, forms an item of continuous study.

Faced with a probable steady increase in the cost of lead, it is essential that efforts be made to reduce the amount of this metal used in electrical glasses. Glasses with zero lead content and having the same electrical properties as the standard 30 per cent. lead oxide containing glass have been made experimentally; on a production scale a glass containing 20 per cent. of lead oxide is now in use.

Work also continues on glasses specially designed for the paassage of ultra violet light in the region of 2537A° (the resonance radiation of mercury) and for infra-red passing.

The use of glass in association with metals, and especially as hermetic seals, as components of heavy as well as light apparatus, is receiving special attention and glass/metal seals fifteen or more inches in diameter are now made with comparative ease. One such seal ready for incorporation into its associated apparatus weighs over 50 lb.

Infra-Red Detectors

An interesting and maybe important effect has been discovered with regard to cooled lead sulphide cells. The detection limit of these cells is known to improve 5 to 10 fold on cooling a typical cell from room temperature to −80° C. (solid carbon dioxide), accompanied by an increase of cell resistance from about 50,000 ohms to 1 megohm. Further cooling, as with liquid air (−180° C.) produces under normal conditions little or no further change. It has been found that this occurs, paradoxically, because the cell now becomes so very sensitive; its resistance is kept low, and its response, so to speak, is saturated by the radiation which it receives from its surroundings if these are at room temperature. If the cell is not only cooled with liquid air, but placed in a box at liquid air temperature, its detection limit for radiation received through a small hole in the box becomes 1,000 or more times better than at room temperature. Under these circumstances a radiation power of less than 10-13 watt can be detected.

A New Method of Factory Lighting

An experimental installation of 2·5 k.w. lamps forms a novel and interesting solution to one of the most difficult problems of factory lighting that are usually classified as high bay lighting. The difficulties are principally because of the need to erect large pieces of machinery, and to have free travel for the necessary cranes and gantries and the height above the floor free from any obstruction (and

the lighting fittings are obstructions) must be as great as possible—50 ft. or more. Yet at the same time the illumination at floor level must be adequate and uniform, the vertical illumination on machines under erection must be satisfactory and the illumination under any side galleries must blend reasonably well with the main lighting. In addition to this, a well-known pitfall awaits the illuminating engineer, that of service.

Importance of Servicing

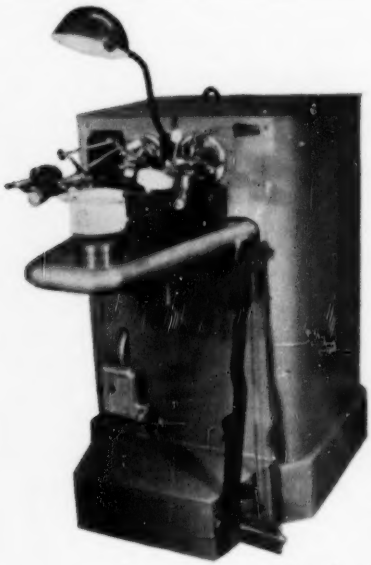
If service facilities for lamp replacement and cleaning are not given equal thought, the brightest design soon deteriorates to a third-rate effort because the factory management finds itself in a most uneconomical and impracticable position when contemplating the servicing of the equipment.

It is thought that all these points have received proper attention in the installation now in operation in a new B.T.H. factory, the lighting equipment for which has been designed by the laboratory in co-operation with the factory engineers. The area to be illuminated measures 500 ft. × 90 ft., and the mounting height for each fitting is 62 ft. Each lighting point consists of one 2½ k.w. mercury vapour lamp and two 1½ k.w. tungsten lamps. The illumination at floor level averages 11 ft. candles. Built-in cat-walks enable each fitting to be approached with safety, and the fittings are reversible through 180 degrees so that servicing is done, not by overhead and uncomfortable working, but as if the fitting were on a bench.

No Psychological Disturbance

Under the galleries illumination is provided by 80 watt fluorescent lamps and the colours of the two schemes blend so that there is little or no psychological disturbance.

The installation is a notable contribution to good working, both for the operatives on the factory floor, and for those who service the installation.



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Joint Industrial Management

Discussion of Mr. Cuthbert Bailey's Paper

(Reported on pages 24-30)

The President (Mr. J. L. Williams) complimented Mr. Bailey on the thought, thoroughness and effort which he had put into the paper, and said that the issues raised by the speaker merited the most close and careful study of the Association members.

Mr. J. Thomas (Wedgwood's, Barlaston) described the paper as "very inspiring," but said he was not sure that an audience of pottery managers could give an answer to Mr. Bailey's challenge. It would be helpful to know what the trade unions meant when they talked about joint management. "I do not accept the suggestion, however," continued Mr. Thomas, "that America leads the way in industrial relations. Britain has made big progress in the field of industrial relations, and without knowing what our trade unions mean by joint management, when Mr. Bailey talks about Americans getting round the table on this matter, I admit I would welcome it if our own trade unionist leaders would get round the table in the same way."

Mr. Bailey: I am careful not to say with any precision from where this joint management demand comes. It comes from a set of trade union leaders. On the other hand, it is denounced as unworkable by other trade union leaders. It comes from the development of labour in some industries, notably the miners, who are increasingly alert in this matter, and who, I understand, express themselves disappointed and dissatisfied that the mines are not owned by the miners and the railways by the railwaymen. That was their idea, and, as one reads in the Press, miners are increasingly demanding a share in the management, although having little knowledge or understanding of the complexities of management, or the necessary training and technical and mechanical foundations that are required to join in management of the mining industry.

Job for Young Aspirants

If this is to be developed at all, it must be developed by young aspirants in the mining industry, with the mental qualifications for the job, being chosen at an early age and being specially trained for the responsibility of management, not only in the complexities of the industry itself, but on the principles that management represents power, and that power must stand for the acceptance of responsibility.

Another member asked Mr. Bailey: In view of your answer, I think it would be possible on a long-term policy, possibly over ten to twenty years, for young men to be trained at technical colleges in the art of management. Will the speaker agree that that might be possible in ten to twenty years, and lead to effective joint industrial management?

Mr. Bailey: Yes, it is the only way in my opinion. Yet I should have some anxiety as to who their teachers might be, because they must be taught all the responsibilities that go with management. As I emphasised in my paper, it is not suggested that workers are not capable of joining in management because of a lack of ability or brains. What they must have, however, is the training. That must be divided into two categories—(1) they are taught the complexities of management, which is personal; (2) they must be taught financial responsibility, responsibility to the country and to the community, and also to the investor, rather than responsibility to any class, whatever class that may be.

A further question put to Mr. Bailey was: Would not the fact that a person who was removed at an early age and taught the complexities of management from the technical and workers' side lead to a position where, when he assumed management, that he would take up the "they" case and not the "we" one?

Mr. Bailey: . . . It might. But you would have new men of intelligence and understanding, and we could do with more of them. Where the average man makes a mistake under the impact of a slogan like joint industrial management is in not realising that man's ability to assimilate facts comes only through long training and experience. The most receptive mental capacity is limited, and when you attempt to fill it too quickly it just flows over. You cannot immediately find these men in the ranks. They can come from the ranks, but they must be trained for the job. Many firms and trade unions would not agree with the idea, but I think this is the only way that joint management can develop. Personally, I would welcome it.

Judging on the Past

Mr. A. Wood (Wedgwood's, Tunstall): Do you not think, in saying that the workers are not too co-operative, that they are judging the position on the past, and on what happened between the two World Wars and in 1926? That does not apply only to the pottery industry, of course.

Mr. Bailey: I have the record of the past very much at heart. I condemn it as heartily and severely as anyone. It is a hateful record. I think that industrialists have often been actuated for the good of themselves. I am not a hard-faced employer, but I have done many things of which I feel guilty today. I am actuated not only by a sense of guilt, but by the consequences of that guilt. The policy of making as large profits as one could by paying employees as low wages as they could be made to work for was all wrong. That was of the past. Let us now remember, however, the country and our future. You cannot work for fathers and mothers any more. I now hate what they went through as much as anyone. But now we are working for our own future and the future of our children, and let us, for God's sake, face the country's future.

Mr. J. Llewelly thought that the attitude of most workers to joint management was linked with the financial aspect. The workers generally, he said, viewed joint management as a means to bigger salaries or wages.

Money-Minded

Mr. Bailey: I move among 1,700 people at my firm, but I have not heard one single word about joint management. My workers say they would not change their job for mine. We want high wages and high production. I would like to see the American system here, whereby the trade unions work within the industrial framework. If it is a big cake, they get a big slice, and when they come into conflict it is usually on the size of the slice. On productivity, the American is much more money-minded than the Britisher. That is one of our troubles; as a nation we are not sufficiently money-minded. If the American workers have one car to every two families they want two to three, and later a car to every family; also a refrigerator and all the other household gadgets. Americans want these things and will work to get them. The ordinary Britisher does not have that attitude. The result is that American productivity simply out-races everyone else's.

Another questioner asked: Is Mr. Bailey of the opinion that industrial management must be at the top plane or at bench level? I am thinking of the case where leaders are being made in actual production. These cases cannot be made without the full co-operation of the worker, and that is, in my view, management on the joint basis. I suggest we could take the principle on the bench level rather than the Board level. That should be the starting point.

Mr. Bailey: That seems to me to strike at the root of the whole matter, and asks, "What is successful management and on what does it stand or fall?" Quite apart from the technical and scientific backgrounds, it seems to me that there are three essential principles. The first and foremost is that *the principal* should leave his office as often as possible, go among the workpeople, and win their confidence and trust.

The second is that he must be absolutely scrupulous about the appointment of managers who have not only technical background, but also the capacity to get co-operation from the workpeople. Thirdly, I would say that the workers are entitled to share in the profits of the firm, and if they are granted that they will work for it. In the same way, in my firm we never attempt to introduce any new scheme unless we first sell it to the operatives. My experience is that if you have the confidence and trust of your employees you can do almost anything with the British working man. But first you have *to win* their confidence, and that is really co-operative management.

Mr. A. J. Clough: The pottery industry has numerous processes, and some of the managers know only some of the processes. The success of a factory depends on co-operating all processes successfully, and one of the things against joint management is that it might be hindered by a person trying to bring forward something he knows little about.

Mr. Bailey: That is the essence of management, as I see it. The man at the top sees the true balance of things, and he works, if successful, on that basis and with a co-operative attitude.

A vote of thanks to Mr. Bailey was proposed by Mr. D. Salt and seconded by Mr. W. Eardley.

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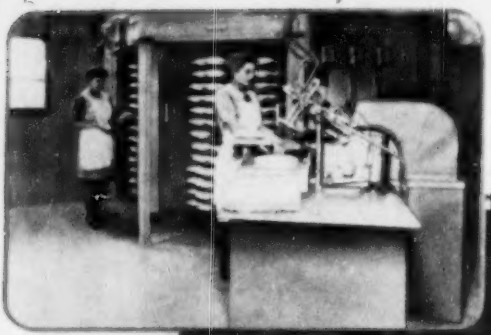

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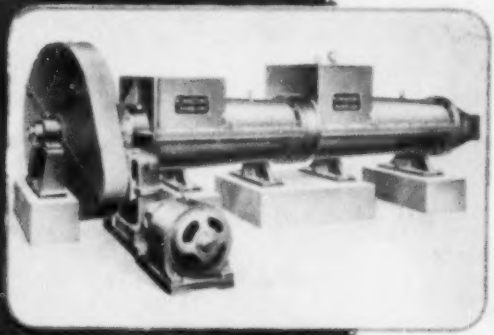

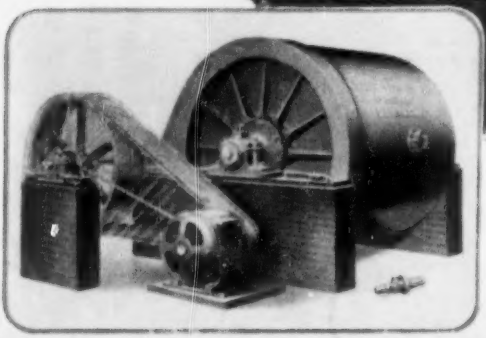

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